COOPERATIVE VEHICLE-INFRASTRUCTURE SYSTEMS

Cooperative Urban Mobility

Exploring the possibilities offered by next generation infrastructure-vehicle communications in tackling urban transport challenges

CVIS is an Integrated Project co-funded by the European Commission under the Sixth Framework Programme for Research and Development

Foreword

As Coordinator of the CVIS project, I am delighted to introduce this short handbook to cooperative systems for city transport professionals. Every member of our consortium has his or her own vision of what it could be like to travel in a world where cooperative mobility systems are widely deployed, and where every car, truck and bus would be equipped to interact with the surrounding intelligent infrastructure and with other nearby vehicles. In reality, we have still little practical experience of how cooperative systems would work in practice, and their real impacts and benefits.

Every CVIS partner has contributed their part to the remarkable achievements that are now available to be transformed into real products. Like me, they are impatient to see cooperative systems out on the road and generating benefits for transport users and operators. The pre-condition for deployment is that the customers for cooperative systems, that is the vehicle buyers and infrastructure owners, are aware of cooperative systems and – more important – understand how they could help them drive more safely, economically and comfortably (drivers) and operate their road networks more efficiently (road operators).

So we hope that this booklet will help you the reader to imagine how cooperative systems could help you to achieve your goals relating to mobility, and then to succeed in your projects to make them happen in your city, your region or your road network.

Paul Kompfner
CVIS Coordinator
ERTICO – ITS Europe

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Part I Why do you need to know about cooperative systems?

This chapter introduces the cooperative systems technology and the CVIS technology: highlighting some of the benefits that the technology could provide, and the stakeholders who need to be involved in the deployment.

Cooperative systems are a promising information and communication technology (ICT) based technology with a vision to deliver close to accident-free, efficient and clean road systems across Europe. Cooperative systems are the next big wave in intelligent transport systems (ITS) which are gaining increasing momentum particularly in Europe as well as the USA and Japan.

This document is intended for traffic managers, transport planners, urban planners and decision makers in local (and regional) authorities, and will raise awareness for the potential of cooperative systems to help meet local transport challenges. The text will introduce current and future cooperative systems and services, discuss the benefits of these services for tackling transport challenges, as well as steps for implementation, possible barriers to implementation, and how to overcome them. This document will not look in-depth at technology issues, but will concentrate instead on how cooperative systems can work to tackle transport challenges mainly in urban areas.

Cooperative systems technologies are gaining increasing momentum: car manufacturers have agreed to equip all new cars with interoperable onboard units for communication, and service providers are likely to come up with attractive applications designed to entice drivers to buy them. Local and regional authorities can benefit from cooperative systems services too: apart from obvious benefits in terms of improved data collection from so-called ‘floating vehicle data’, applications are being designed and developed to benefit cities. The technology has had years of research and development, and now the real interest is in looking at the deployment of cooperative systems, with a vision for deployment in 2020. This is why this text is of interest now: it is time for local authorities to think about how cooperative systems services can be used to benefit their cities.

This document is in five parts: the first part introduces cooperative systems and explains why they are of interest to local transport authorities and transport planners. Part II looks at how cooperative systems tackle local transport challenges, and this section focuses heavily on applications which are separated into five policy areas: road network management, safety, freight management, public transport, and environmental impacts of transport. Parts III and IV look at deployment issues: technological aspects are considered along with costs, business models, and other non-technical issues related to deployment.

The final chapter (part V) looks at existing evaluation studies as well as planned field operational tests (FOTs) and where cooperative systems fit in to the European ITS Action Plan.

The document is written as part of the Cooperative Vehicle Infrastructure Systems (CVIS) project, and as such it will concentrate on applications within this project (See page 10).

Introduction to cooperative systems

Cooperative systems are systems by which a vehicle communicates wirelessly with another vehicle (V2V – vehicle-to-vehicle communication) or with roadside infrastructure (V2I – vehicle-to-infrastructure communication or I2V – infrastructure to vehicle communication) with the ultimate aim of achieving benefits for many areas of traffic management and road safety.

The basic idea is that vehicles are equipped with onboard units, routers and antennae: thus they can receive information from roadside infrastructure, process information, display information to the driver (or passengers on public transport) and communicate information with other vehicles or with roadside infrastructure fitted with the right technology. Information is passed wirelessly through a variety of short and long range communication media (such as the mobile phone network).

There are already examples of vehicles communicating wirelessly with roadside infrastructure: for example bus priority at traffic lights where the bus is fitted with technology which communicates with the traffic light in order to get priority for the bus lane ahead of the general traffic lane. As the bus approaches the traffic light, it communicates with the traffic light to tell it that it is approaching, and the traffic light can accept (stay / turn green) or deny (stay / turn red) the request. Such a system is cooperative in the sense that is based on the transfer of data through wireless communication (from the bus to the infrastructure). However, existing systems are referred to as standalone or autonomous systems, since the platform on which they are built are designed to handle only one single application and cannot easily be adapted to add new services or applications. Additionally, the communication is only one-way (from bus to traffic light): the driver does not receive any information from the infrastructure (eg on whether the request for green is granted).

What is novel in next generation cooperative systems technology is precisely this: the basis of the new technology allows for **two-way communication** over an **open platform** which allows for many different services and applications to be added to it with ease. Thus the cooperative systems are 'cooperative' on two levels: firstly in terms of direct two-way communication (V2V, I2V and V2I), and secondly in terms of an open platform which allows for multiple applications and services to be implemented by any vendor.

Cooperative systems around the world

Cooperative systems technology developments are moving fast in both North America and in Japan, with large-scale national programmes supported by substantial dedicated budgets in both the USA (notably IntelliDrive project (formerly Vehicle Infrastructure Integration (VII)) which started in 2005) and Japan (notably Advanced Safety Vehicle (ASV) project). As is often the case with new technologies, the term 'cooperative systems' is not the de facto term used for the technology across the world, or even across Europe. Often the technology is referred to V2X, in-vehicle communications or VII (the former name of the North American project). The description of the technology and its benefits given in this handbook is the same no matter what the name.

There is heterogeneity to the approach of European Member States to cooperative systems. There are already several cooperative systems initiatives that have been launched in European Member States, for example INVENT and SIMTD in Germany, CVHS in the UK, PREDIT in France and IVSS in Sweden. The Netherlands is the most advanced in Europe in their approach to cooperative systems, having even developed a policy towards cooperative systems and a roadmap for deployment.

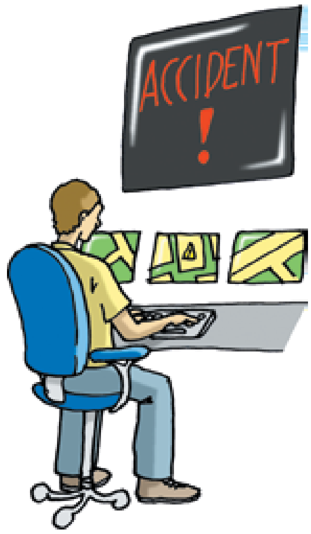
There are also several major European projects on cooperative systems: CVIS, Safespot, Coopers which are dedicated to design and test cooperative systems technologies. Other projects include the eSafety forum (www.esafetysupport.org); Car 2 Car Consortium (www.car-to-car.org); COMeSafety (www.comesafety.org), and others, a comprehensive list of which can be found here: www.cvisproject.org/en/links/

It is the universality of cooperative systems that makes the technology novel: whereas existing wireless communications technologies provide different systems to tackle different transport problems, now cooperative systems allow for one solution to provide the basis to solve many problems. The wide range of applications and urban transport challenges that could be tackled by cooperative systems is introduced in this text.

The benefits of intelligent cooperative systems stem from the increased information that is available from each vehicle fitted with the technology and the coordinated manner in which this data can be managed, as well as the possibility of giving individualised information to drivers. The communication allowed for by cooperative systems technology provides real-time information about the location of vehicles (so-called 'floating vehicle' data), and (through this) of road conditions which allows road operators high quality information to make better-informed decisions in response to accidents, hazards or congestion. Eventually traffic management reaches into the vehicles where relevant information can be given to influence driving behaviour (eg cruising speed, route choice).

The benefits of cooperative systems include:

- improved quality of real-time traffic data;
- improved management and control of the road network (both urban and inter-urban);
- increased efficiency of public transport systems;
- reduced emissions and pollution;
- improved traffic safety for all road users;
- reduced congestion;
- more efficient logistical management;
- better and more efficient response to hazards, incidents and accidents;
- shorter and more predictable journey times;
- lower vehicle operating costs.



The CVIS Open Platform

CVIS provides an open platform on which many different applications can be implemented. The capabilities of this open platform were demonstrated in the CVIS application innovation contest. This innovation contest, launched in January 2009, aimed to stimulate innovation by developers both within and external to the project to develop CVIS-compliant services. A large number of high-quality concepts were submitted, and the best four were invited to demonstrate their applications during the ITS World Congress in Stockholm in September 2009.

Halmstad University is the winner of the CVIS Application Innovation Contest 2009

Press Release

Stockholm, 24 September 2009.
Kristofer Lidstroem from Halmstad University in Sweden claimed the top prize in the final of the CVIS Application Innovation Contest 2009 which was held at the 16th ITS World Congress in Stockholm. The second prize was taken by Lodgon, Belgium and the two third prizes were given to Ygomi and CIT. The companies were awarded €20,000, €15,000 and €7,500 respectively.

Halmstad University took gold with a pedestrian safety system where the vehicle informs the intelligent intersection when the system detects that the driver is behaving unpredictably. Both driver and pedestrian are warned either through the HMI displays in the car or on a mobile phone, or by altering traffic light phases. The driver behaviour is compared to reference models implemented using a potential field approach.

Interview

Toine Molenschot, City of the Hague, Department for Urban Development

How do cooperative systems tackle urban transport challenges?

Cooperative systems help to improve overall traffic management by increasing data availability through floating car data, decreasing traffic congestion and improving traffic/road safety. At present, messages can only be placed in certain places (VMS (variable message signs)), so cooperative systems can broaden the reach of users who will be able to see the messages on their InCar system and this will have benefits in terms of managing the roads. Additionally, data sensors can be used to rearrange traffic flows based on emissions, a task that will be made easier with cooperative systems technology.

Although the technology promises a lot, it is difficult to tell what scale of benefits will be possible until large scale tests are performed to see if the technology can provide the benefits on a large scale. It is also critically important to use the data gained well.

How do cooperative systems fit into an overall traffic management / ITS strategy?

In the future, there will be more opportunities to inform road users (for example on location based services) about the current traffic situation (through route guidance, travel time, events or incidents), but also more opportunities to direct traffic across the network. With enhanced data knowledge for the local authority, and knowledge of origin-destination data, specific route guidance can be given for the whole network, and problems whereby congestion is shifted from one area to another can be avoided since the route guidance can be personalised, and problems will not just be shifted from one area to another.

Additionally, cooperative systems can provide us with a tool to inform about alternative modes, such as park and ride, thus promoting modal shift, and cooperative systems can be used as a tool to improve traffic safety, especially towards vulnerable road users (for example at urban intersections).

What are some major challenges to deployment?

Some of the main challenges to deployment are: the choice of system(s) and architecture; communication protocol; cooperation with service providers / business plan; costs (we need the best, but least expensive solution); legal issues (eg new enforcement law that London had to make just for the test site – takes time and a lot of effort!); privacy and security issues (after the announcement of road user charging in the Netherlands, it is clear that privacy is a big issue for private car users, and this needs to be addressed in cooperative system technology).

“Although the technology promises a lot, it is difficult to tell what scale of benefits will be possible until large scale tests are performed.”

What is CVIS?

CVIS (Cooperative Vehicle-Infrastructure Systems) is a major European research and development project with the aim to design, develop and test cooperative systems technologies. It is supported by the European Commission under the 6th Framework Programme for Research and Development. The project's ambition is to begin a revolution in mobility for travellers and goods, completely re-engineering how drivers, vehicles, goods and transport infrastructure interact. The project has over 60 partners bringing together a mix of public authorities, software developers, system integrators, road operators, public transport operators, system suppliers, vehicle manufacturers, research institutions and users' organisations. The project started in February 2006, and with a large budget and wide variety of stakeholders involved, it is an important project in the development and the deployment of cooperative systems technology in the EU.

This text is being written as part of the CVIS project, so most of the example applications here will focus on those in the project, although not exclusively so. Examples applications include those in urban areas, interurban areas and freight and fleet applications. Four examples of applications in the project include:

- Priority application: priority can be given to certain vehicles (such as emergency vehicles or public transport vehicles) in the network, for instance at intersections or along pre-defined road segments. The priority application resembles existing priority applications (for example for trams and buses), but differs in the level of sophistication, and range of application.
- Hazardous goods shipment: goods can be tracked at all times and have priority along a pre-selected safe route. In case of an incident or accident, the dangerous goods vehicle can be rerouted or the local authorities can react in a responsible and adequate way.
- Enhanced driver awareness: a safety application that will inform vehicle drivers within 5 seconds about relevant aspects of the dynamic traffic situation: current speed (or other) regulations, road and weather conditions downstream, etc.
- Strategic routing for vehicles (goods vehicles, taxis or private vehicles): the urban routing system receives the strategy defined by the traffic management centre (which may depend on weather conditions or if there are large events in the city such as a football match etc.), and uses this strategy to make an optimal individualised route calculation while also taking into account other vehicles in the network and historical traffic data.

Application to help drivers in interurban settings. Source: CVIS

Applications are the most visual part of CVIS, but of course there are other equally important technological issues that CVIS is working on to make these applications happen. Other key features include high-precision positioning and local dynamic maps; a system for gathering and integrating monitoring data from moving vehicles and roadside detectors; and a secure and open application framework to allow access to online services. An 'open' application framework is one which – in terms of software at least – is available for anyone to use (and update and modify) with very few or no copyright restrictions: this is a useful feature for software in such a large project as CVIS spanning many different countries and industries.

Cooperative urban (CURB) navigator, used in the strategic routing application. Source: PTV

Additionally, CVIS will look at defining an architecture for the cooperative systems technology within the project (in coordination with other projects and stakeholders). An 'architecture' refers to a method used to ensure that all of the component parts involved in making cooperative systems (the hardware, the software, the people who work on it, etc) work together effectively to form a working whole.

CVIS technology can only work if there is full interoperability in the communication between different makes of vehicle and between vehicles and different types of roadside systems. By bringing together different manufacturers in the project, and helping to drive the impetus for the development of standards, CVIS not only ensures interoperability within the project, but also creates a legacy to drive forward interoperability in cooperative systems technologies of the future.

In order to keep vehicles continuously connected, CVIS has developed a mobile router that can switch seamlessly between different forms of communication media (such as mobile cellular, wireless local area network, short-range microwave or infra-red), to link vehicles continuously with roadside equipment and servers.

To validate the project's results, all CVIS technologies and applications have been tested at one or more test sites in seven European countries: Belgium, France, Germany, Italy, the Netherlands, Sweden and the UK.

CVIS pan-European deployment: test sites, and other sites where CVIS is being deployed

The overall CVIS objectives are:

- To create a unified technological solution which allows all vehicles and infrastructure elements to communicate with each other and with roadside infrastructure in a continuous and transparent way by using a variety of media.
- To enable a wide range of potential cooperative services to run on an open application framework in the vehicle and roadside equipment (like on the iPhone©: so anyone (who understands the code well enough) can design applications).
- To define an architecture and a system concept for a number of cooperative system applications, and to develop the basic tools necessary for deployment of cooperative systems for public authorities, operators, service providers, industry and other key stakeholders.
- To address issues such as user acceptance, data privacy and security, system openness and interoperability, risk and liability, public policy needs, cost/benefit and business models, and roll-out plans for implementation

Along with the technical aspect, CVIS also examines deployment challenges related to cooperative systems, and addresses non-technical questions which will affect the adoption of cooperative systems technology. The aims of the "deployment" branch of the CVIS project are

- To ensure that the core technologies and applications are deployable and that non-technical issues have been identified with possible solutions addressed, and
- To create roadmaps detailing how to achieve a future with widespread take-up of operational CVIS systems.

Source: Volvo Technology Corporation

CVIS intends to produce the following key results:

- a router capable of maintaining a continuous internet connection over a wide range of media (eg cellular, mobile Wi-Fi networks, infra-red or short-range microwave), while ensuring full interoperability in the communication between different makes of vehicle and of traffic management systems;
- an open cooperative systems architecture that can easily be updated or enhanced to allow for changes in technologies;
- techniques for enhanced vehicle positioning and the creation of local dynamic maps;
- improved data sharing between vehicles, roadside infrastructure and service centres for traffic, weather and environmental data;
- application design and software development for the following:
  - cooperative urban network management
  - cooperative area destination-based control
  - cooperative acceleration/deceleration
  - dynamic bus lanes
  - enhanced driver awareness
  - cooperative traveller assistance on inter-urban highways
  - commercial vehicle parking
  - loading zones booking and management
  - monitoring and guidance of hazardous goods
  - freight vehicle access control to sensitive areas
- Deployment enabling toolkit in the form of models, guidelines and recommendations in the areas of: openness and interoperability; safe, secure and fault-tolerant design; utility, usability and user acceptance; costs, benefits and business models; risks and liability; cooperative systems as a policy tool; and deployment roadmaps.

For more information on CVIS, and access to project deliverables, please visit www.cvisproject.org

How can cooperative systems tackle urban transport challenges?

Cooperative systems provide a technology that will – as part of a dedicated transport policy – help to solve current transport challenges: help to increase road safety, improve the efficiency of public transport and of freight vehicles, increase traffic efficiency and reduce congestion and decrease the environmental impact of road transport. This document will help to explain exactly how these benefits can be delivered, and how cooperative technology can start to be deployed to achieve these aims.

The benefits are due in large to the fact that network management systems will be able to interact with vehicles individually (or with groups of vehicles of the same type) rather than dealing with averaged group behaviour. This new level of detail will provide a more precise view of the transport network than is possible at present and will lead to benefits for public transport operators, freight and fleet managers as well as general transport managers and private road users.

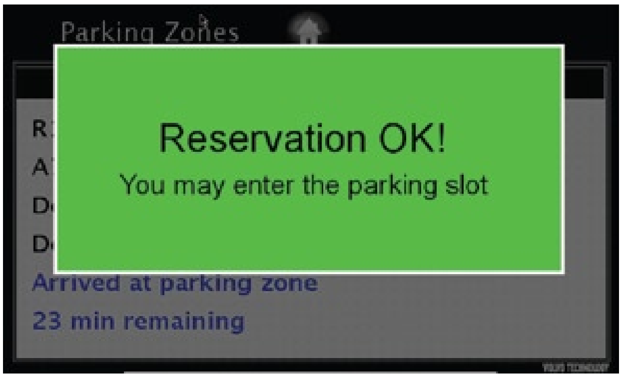
The following show possible ideas of what cooperative systems can offer, and how they can bring about benefits in various key policy areas: these are suggestions, and are not exhaustive! Some of these ideas are CVIS applications that will be extended fully in the next chapter.

Benefits to public transport operators and freight management...

Public transport patronage is increased when there is better information about the public transport system[1]: for example, someone waiting at a bus stop prefers to know exactly where a bus is and how long they will have to wait given current congestion conditions, rather than rely on printed timetables in the bus stop. Even though such RTTI (real-time traffic information) systems are already in existence in many cities, the cooperative systems technology is organised in an interoperable way to allow for flexibility and easy extension, whereas current systems are designed for only one purpose, and such flexibility is not built in.

Additionally, if for any reason a bus or tram is severely delayed, in a future world of cooperative systems, an application could be designed so that passengers could receive alternative real-time rerouting information to their mobile phone or on screens in the bus to major transport hubs in the city.

It is not just data that is improved: with cooperative systems, a CVIS application has been developed to grant green priority to vehicles. Special priority can be given to classes of vehicles for improved efficiency where it counts most: for emergency vehicles, public transport vehicles and goods vehicles. These types of priority may already exist, but the priorities granted with cooperative systems are more intelligent: a bus may not always need priority, if – for example – it's ahead of schedule, or if the traffic situation requires priority to be given to traffic from another direction instead. These conflicts in priority can easily be included within cooperative systems applications because communication is organised in an interoperable way, allowing for flexibility and extensibility. Additionally, because of the two-way communication allowed by next generation cooperative systems, not only will vehicle drivers be able to ask for priority, but feedback to the driver can also be given.



Screenshot from parking booking zone application.
Source: Volvo Technology Corporation

Other possible cooperative applications concentrate on goods shipments. Vehicles fitted with cooperative systems technology can be easily tracked, and within urban areas, special routes can be planned for freight vehicles, and time restrictions for entering zones and for loading and unloading can be conveniently communicated to drivers even if they are from out of town. The transport of hazardous goods can be tracked and such goods can follow pre-defined safe routes to minimise any risks to the population.

Increased safety…

There are 39,000 road traffic related deaths per year in Europe[2], and this is an unacceptably high figure, even if it has been reduced significantly over the years. The reductions in road casualties are due to increased safety awareness, safer vehicles and infrastructure, and safety policies and legislation – for example regarding seat belts and alcohol consumption. Cooperative systems can help reduce accidents and casualties even further.

One way in which cooperative systems can reduce accidents and casualties is by warning drivers of imminent collisions. The ability of cooperative systems to extend a vehicles' field of vision with enhanced communication capabilities allows vehicles to 'look around the corner', thus helping the vehicle to avoid collisions with other vehicles or with pedestrians or cyclists.

Because of constant contact between vehicles and roadside infrastructure, cooperative systems can give out safety alerts if there has been an accident, or if there are bad weather conditions (eg an icy patch on the road).

Cooperative system technology is also key in implementing intelligent speed adaptation which will help motorists keep to the speed limits, even if the speed limits are variant.

Increased efficiency…

The wireless communication at the heart of the cooperative systems technology will allow traffic management systems to communicate with individual vehicles: this will provide a two-way increase in efficiency as information about traffic, incidents and hazards will be available for the entire network, and will contain far more detail than today's traffic information broadcasts.

First of all, traffic managers will know exactly where vehicles are situated and where congestion is occurring: this so-called 'floating vehicle data' will enhance the information given to real-time traffic information systems and enhance the efficiency of traffic management systems. Secondly, the cooperative road network will adapt in real-time to actual demand: relevant information will be communicated directly to the driver's onboard unit (OBU) who will be able to react immediately to new information rather than having to wait until they hear or see the next traffic information broadcast. This two-way communication will enable a more efficient use of existing road infrastructure.

Experience with taxis in Vienna shows that when only 3% of the total vehicle fleet is equipped with cooperative system technology, there is already an improvement in the quality of data fed into traffic management systems.

Parking management is another area which could benefit from cooperative systems applications: for example, a possible parking application could show drivers on their OBU where parking spaces are available, and also allow them to book spaces in advance. Existing examples such as OPTIPARK and IPark4U currently exist as standalone applications that could be integrated into the cooperative systems environment. This type of application will ultimately save time and money in searching for parking spaces. Local authorities could communicate parking restrictions from roadside units, bringing the information in-car: this would reduce time and money for the driver looking for parking spaces, as well as implement restrictions relevant to accessibility, and ultimately reduce congestion.

Benefits for the environment...

Cooperative systems offer the potential to reduce congestion by creating additional effective road network capacity, and a more efficient utilisation of the existing network. Additionally – as long as cooperative systems are introduced within a dedicated policy to do so – it is envisaged that traffic will flow more smoothly with fewer stops, thus may also improve air quality.

Applications which make parking more efficient will reduce time spent looking for parking spaces, thus reducing time spent on the road, and possibly also congestion at peak times. Speed advice applications (in combination with priority applications) are designed to produce green waves, with the aim to have environmental benefits: vehicles will communicate with roadside infrastructure to travel at the optimum speed so that they are not required to stop at traffic lights, thus reducing the stop-and-start behaviour which produces more emissions and congestion than continuous traffic flow. This is especially of interest for heavy goods vehicles: cities would benefit particularly from reducing stop-and-start driving of this class of vehicle, and cooperative systems technology provide a method to do this.

These possible cooperative systems applications come hand-in-hand with less fuel consumption, less emissions, and ultimately better air quality in cities, and reduced impact on global climate change.

What's the catch?

If cooperative systems are so effective and produce such benefits, why have they not been implemented yet? The answer is clear: the technologies that are needed to create applications where vehicles and roadside infrastructure can communicate with each other directly (on a large scale) are still being developed. It will take time for the full benefits of the technologies to be shown, and for full deployment to become a reality. Small scale examples exist and are being tested within projects such as CVIS, but cooperative systems have yet to be implemented on a large scale.

Indeed there are still some challenges to be faced by those developing cooperative systems technologies: for example, although positioning is becoming more and more precise, it still has not reached the accuracy (under all circumstances) where vehicles can be positioned within a lane on a road, and some cooperative system applications will require this level of precision. Additionally, some applications (especially the safety applications) will require a constantly secured high speed connection in order for users to be assured that they can rely on the application, and how this connectivity can be assured in large-scale deployment has still to be shown. Issues such as stability, reliability and interoperability of the systems also need to be ensured before the systems can be deployed on a large scale. However, the technologies are being tested and adjusted to solve these issues.

Additionally, it is clear that although cooperative systems technologies promise to provide significant benefits in many areas, a technology cannot solve problems by itself: if cities are overly congested, then applications will not provide the awaited benefits. The deployment of cooperative systems should be delivered within a dedicated policy framework suitable for the area under question: cooperative systems (and ITS in general) are a measure to help solve urban transport problems, and should be implemented along with other measures and strategies to ensure that the benefits mentioned in this document can be achieved.

Who are the different stakeholders involved?

One of the complicated issues with deploying cooperative systems is that there are many actors involved who need to work with each other. The users of the system are public authorities, but also road operators, freight and public transport operators as well as private road users. This is not to mention those who make and design the applications: vehicle manufacturers, equipment manufacturers, research institutes and software developers; and those providing the final services to the users (on a business case basis). Each of these user groups will benefit from cooperative systems once they are deployed, but the full benefit will only be felt as long as all of the groups are willing to invest.

Local authorities are key stakeholders in the deployment process of cooperative systems, but V2V applications can and will be deployed without their input. Additionally, V2I and I2V applications will be deployed on regional and national roads without the involvement of cities. With many different stakeholder groups involved, there may be conflicting objectives for different user groups. In order to maintain the objectives of local authorities, local authorities need to stay well-informed and to get involved in the deployment of cooperative systems technologies.

Creation & development of system:

- Vehicle manufacturers
- Equipment manufacturers
- Research institutions
- Software developers

Users:

- Local authorities
- National road authorities
- Road operators
- Freight operators
- Public transport operators
- Private road users

Promoters:

- Users' organisations
- Transport organisations
- Service providers

Interview

Gerbrand Klijn, Noord Brabant (Regional Authority)

How do cooperative systems tackle urban transport challenges?

Cooperative systems are novel, even for a high tech region such as Noord Brabant which prides itself on keeping apace with innovation. There are several ways in which cooperative systems help to tackle transport challenges, although these are mainly in terms of safety, and in improving traffic streams. Cooperative systems are on the shorter term perhaps better at tackling challenges in interurban systems than in urban systems, because of the relative ease of interurban systems and better penetration for GPS.

How do cooperative systems fit into an overall traffic management / ITS strategy?

In order to introduce cooperative systems, we have a several stage vision. The first step is to have tests on simple stretches of regional roads, the second step to have tests on regional networks, the third step to have tests on an (inter)national level with information passed through navigation systems and mobile phones. The 4th step is to have full cooperative systems, where the drivers as an intermediate are no longer required. The strategy is under development, but since the technology is so novel, a policy framework has not been specified yet. It is important to perform tests which will be done in the Noord Brabant area, and cooperative systems fit with our profile as a leader in technologically driven solutions.

What are the major challenges to deployment?

Major challenges to deployment include: public acceptance (as drivers do not want to feel that they are losing control), ensuring safe/good interaction between driver and HMI interface, cooperation between large groups of private and public parties and ensuring high enough penetration rates for the technology to be a success.

What is your vision for cooperative systems?

Cooperative systems provide a real opportunity for us: we have many research institutes and many problems with traffic jams. Being a leader in the development of cooperative systems technologies could potentially mean creating an export product. This could be a real opportunity for the region.

> “Cooperative systems provide a real opportunity for us.”

Part II How do cooperative systems tackle urban transport challenges?

This chapter reviews a selection of available cooperative applications relevant to urban areas. The applications are divided by policy area: traffic management, safety, freight management, public transport, and environmental impacts of transport.

The chapter looks at possible applications that could be applied within the CVIS platform. The applications are divided into five policy areas: traffic management, safety, freight management, public transport, and environmental impacts of transport.

These applications form a basic set of applications that could be deployed, but many other applications are possible. Once an open cooperative systems platform (such as CVIS) is installed, traffic managers, service providers and others are likely to develop new applications in order to address any needs of transport managers or transport users. This can be compared to the iPhone©, where one company provides the platform and many stakeholders develop and share applications through the so-called 'app store' due to the openness of (specific parts of) the iPhone© platform. The attractiveness of cooperative systems results from the seamless and comprehensive design of the platform.

Basic functionalities required by (almost) every application are included. This allows application providers to concentrate on the core business case of their application without having to worry about communication (eg with other applications or parts of the application itself distributed on different platforms) or software management.

Within this chapter, the sections on traffic management and freight management include specific applications developed in the CVIS project, while the section on safety includes applications developed in the SAFESPOT project.

For the sections on public transport and environmental impacts of transport, no specific applications have been designed in the CVIS and SAFESPOT projects yet. These sections look at what other applications can contribute to enhance public transport and reduce environmental impacts.

Each application in this section is described, the benefits outlined, and the specific requirements needed for its implementation are presented. All applications are dependent on a basic cooperative vehicle-infrastructure system, for which the basic elements are the following:

Roadside units (RSUs): The roadside infrastructure must be equipped with cooperative technology. This can usually be realised by extending an existing roadside system. A cooperative RSU includes a host to run the applications, a router to manage the communication, and necessary elements (eg antennae, GPS, maps, etc…) for the different communication modes (e.g. dedicated short range communication (DSRC), GSM, wireless LAN).

The number of RSUs needed is dependent on the type of application that is to be deployed. For example, intersection safety applications can be applied to one intersection with a limited number of RSUs, whereas routing applications need a higher number of RSUs on the road network.

Example of an RSU. Source: Siemens

Vehicles must be equipped with a cooperative onboard unit capable of running applications and communicating with roadside units, other vehicles and eventually handheld cooperative devices. Of course, the OBU must have access to an HMI to allow communication with the driver.

Example of a CVIS-equipped vehicle (in-vehicle component). Source: Peek Traffic

The central system or traffic management centre must be able to collect and process data (including fusion of data from different sources, cooperative and non-cooperative), and to communicate data to the RSU and the vehicles, which is readily usable by the driver.

In principle, the vehicle, RSU and centre are built on the same CVIS platform, or – in other words – there is no technical difference between the platform types apart from the way in which they are used by applications installed on them.

The platforms feature convenient software management and communication services which allow software to be installed on any platform (according to the principles governed by the host management centre responsible for the platform in question) as well as communication between platforms.

Thus an application can be uploaded to the OBU when needed (eg when approaching a zone with restricted access, or an area where a cooperative routing service is offered) avoiding any need for pre-installation.

For the implementation of the CVIS platform, further details regarding hardware and software, cost and business models can be found in Part III of this document.

Traffic management

The major traffic management goal in urban areas is to make the best use of road capacity considering the road class, its function and all road users. Traffic management is about optimising the movement of people and goods: in many urban areas, this aim goes hand-in-hand with reducing congestion, and there are many measures which could be introduced to ultimately achieve this aim. The following CVIS applications help to increase the efficient use of existing road infrastructure, and ultimately reduce congestion.

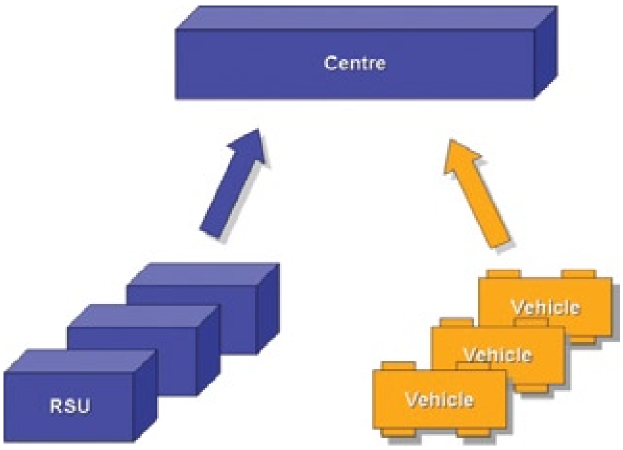
Traffic Mobility Centre in Rome. Source: Roma Servizi per la mobilità

Floating Car Data / Traffic Control Assessment

Basic description

Traffic Control Assessment (TCA) is an application which collects data to assess and validate the configuration of urban traffic control (UTC) systems.

The application integrates information from infrastructure (eg loops and cameras) and floating vehicle data to feed back to a control centre (see figure) where the up-to-date data is integrated into the UTC systems. Currently, validation and calibration of UTC systems are problematic, and the ease of data collection through cooperative systems allows for this to be done easily within this application.



Traffic Control Assessment: RSUs and equipped vehicles send data to traffic management centre. Source: Thetis

Benefits

Vehicles which are equipped with cooperative system technology (such as CVIS technology), will collect information while driving on the road network.
The information gathered by these vehicles (location, travel time, congestion, incidents in network, etc.) will feed back to the urban traffic control system. The application will:

- identify whether the UTC system requires maintenance (for example whether optimisation of the current configuration should be carried out).
- identify problematic areas of the road network: for example where a new controlled intersection could be built or where planning activities (such as road works or adapted traffic rules) could be considered.

The Traffic Control Assessment application is not designed to directly improve efficiency, but it is a tool for traffic control maintenance: it is an indirect tool to support the urban traffic control system in directly altering the road network management conditions.

In current UTC deployment, calibration and maintenance are major issues. Demand management systems provide information only on a macro scale, but there is a lack of precise information on micro level (eg intersection level): the TCA application fills this gap, providing high-level information on a micro-scale to UTC systems for constant calibration and maintenance.

Traffic Control Assessment can be applied to individual vehicles, thus can be put in place with extremely low levels of penetration. It is an application best suited for highly congested urban areas.

Requirements

The application has been designed to be integrated with certain specific traffic control systems (eg the UTOPIA system). The application needs to be integrated with the UTC system being used in the local authority.

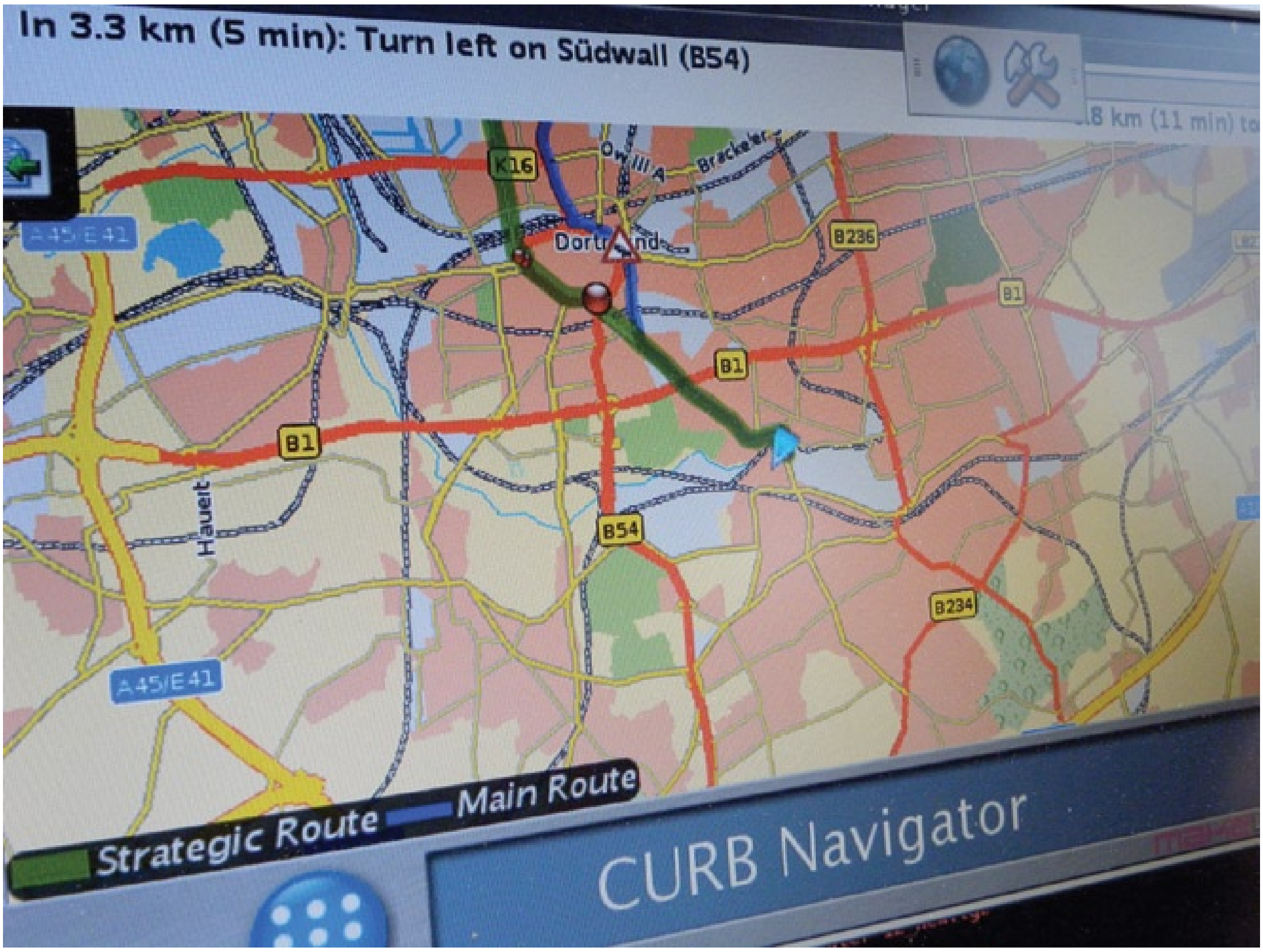
Summary: Why should investment be made in the application?

This application can improve the accuracy of existing traffic control systems. The application can readily be included along with general cooperative systems roll-out, because a very low penetration rate is required for considerable additional benefit.

Strategic Routing

Basic description

Public authorities define strategies in order to regulate traffic in case of serious disruption (such as recurrent traffic congestion, long-term road works or special events), and the urban Strategic Routing Application (SRA) provides enhanced routing functionalities that take into account these pre-defined strategies. The new aspect of this application compared to existing approaches is that route suggestions take into consideration not only network strategies but also real-time traffic information and give individualised routing suggestions to each vehicle. Currently personalised routes are computed on the basis of a (static) map of the network and available traffic information (eg traffic management centre, statistical traffic loads on road sections etc.), but are not harmonised with network management strategies. This may lead to awkward situations where the personal navigation system recommends a different route compared to road signs (eg variable message signs). By transmitting the strategic routes into the vehicles, drivers can be guided to their destination avoiding the worst congestion, with the traffic manager's strategy remaining at the heart of the rerouting.



Cooperative Urban (CURB) Navigator shows Strategic Routing Application. Source: PTV

Benefits

Giving individualised re-routing suggestions that take into consideration pre-defined strategies for re-routing in case of serious disruption and real-time traffic information increases the overall road traffic efficiency compared to the current situation where drivers receive (re-)routing advice from satellite navigation systems which do not take public traffic management strategies into account.

In terms of transport efficiency, the benefit is primarily in terms of improved network performance through a more efficient use of the urban road network. This ultimately can bring about benefits in terms of reduced congestion and reduced emissions.

Requirements

This application requires the following specific settings:

- RSU: The roadside infrastructure must be equipped with the functionality of communicating strategy information harmonised with current strategies for collective routing and traffic control.
- Management Centre(s): There must be a traffic management centre which has the capacity of creating and implementing routing strategies. Additionally, the traffic management centre must be able to interface with the current traffic situation, as well as the dynamic routing portion of the strategic routing application.
- Local authorities would need strategy editor (software) in order to define routing strategies based on analysis of historical data and collective strategies such as traffic control and collective routing. The cost of the strategy editor is not high.

The number of RSUs required in order to communicate routing and strategy information to vehicles is dependent on two issues:

1. The network in question
2. The area that the strategy is provided for

If an area in the network does not provide many possible routing decisions, then not many RSUs need to be installed for this application; they need only be installed at the major intersections where decisions on routing would need to be made. If however, there are many possible different routes that would be compatible for the strategy, the routing system, and the network, this would warrant significant coverage of RSUs (at small and large junctions, at regular intervals along the roadside), so that the vehicles could stay in constant contact with the control centre, and be updated regularly with relevant routing information.

Summary: Why should investment be made in the application?

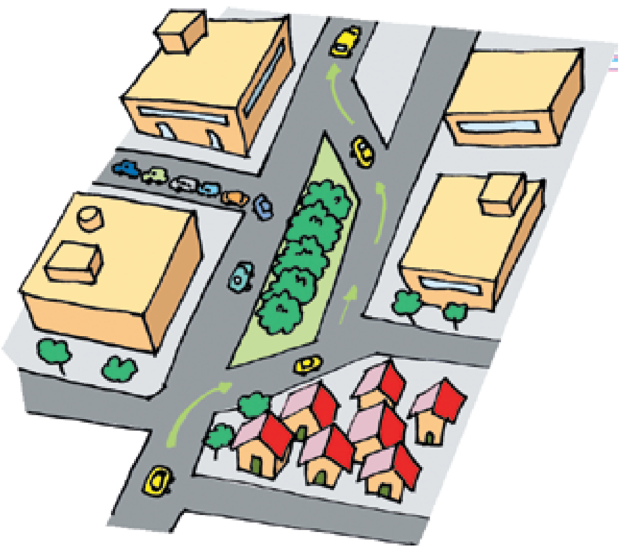
The harmonisation of individual routing services (currently only available via satellite navigation systems) with collective routing and traffic control strategies from public authorities (road operators) will lead to a more efficient exploitation of the network's resources and will reduce congestion and travel times over the full network.

Strategic Routing in Dortmund. Source: PTV

Micro-Routing

Basic description

The Micro-Routing Application provides urban routing advice for drivers (freight and private drivers) taking into consideration factors such as pollution levels, weather forecast, events (eg football match) or local congestion. The application is “micro” since travel information is given for a short time horizon of 1- 5 minutes and only for the direct vicinity of an event (eg a few blocks). Dynamic routing of drivers in the urban context aims at the reduction of congestion, environmental impacts and travel time within the urban network, thus reducing air pollution and providing a more efficient use of the urban road network.



Micro-Routing Application. Source: CVIS

Benefits

Benefits of the application include fewer stops and less time delay at intersections for the vehicles and less travel time from origin to destination. These benefits are at first individual but also improve the network performance as a result of better balancing of traffic. Furthermore, noise levels and emissions will decrease. The application is most useful at intersections on main arterial routes.

For collection of floating car data, this application provides information on delays at controlled intersection per vehicle category, which can be relevant data for monitoring of the efficiency of the network.

Requirements

The number and location of the RSUs depends on where the local authority will want to implement the micro-routing application. RSUs need to be fitted at all intersections where (new) routing information needs to be communicated to drivers.

The system is perfectly able to operate on a standalone basis. The benefit increases if there is cooperation with nearby intersections that also run the Priority Application.

Step-by-step deployment is possible and also encouraged to allow for price reduction. Bottlenecks could be a good place to start as well as certain (smaller) vehicle fleets. The scale can increase incrementally by equipping other locations and fleets.

Summary: Why should investment be made in the system?

The Micro-Routing Application helps to ease the traffic situation over small areas, can be introduced on an incremental basis to facilitate deployment and is designed to work alongside the Priority Application for added benefit.

Priority Application

Basic description

Some vehicles deserve higher attention than others, for instance emergency vehicles, public transport vehicles, heavy trucks or trucks with dangerous goods. The priority application leads to a manipulated switching of traffic lights. The application aims at a more fluid and safe intersection crossing for the vehicle categories set by the authorities. The application can be used in all kinds of urban areas.

Priority Application: in-vehicle component screen. Source: Siemens

Benefits

The benefits depend on the category of vehicles that are granted priority.

Emergency vehicles are usually prioritised (against other road-users) at intersections on pre-defined routes. The cooperative priority application can increase traffic safety at the intersections and flexibility of route choice. Drivers of the non-prioritised vehicles as well as pedestrians and cyclists will have an unambiguous red signal instead of current practices of eg an emergency siren which is often difficult to interpret in terms of its location.

Additionally, current emergency vehicle services are usually based on pre-defined routes and do not allow alternative routes. The Priority Application can increase flexibility of route choice since the software can be uploaded to any cooperative intersection and thus the route choices can be enlarged without extra costs. The real-time traffic situation can be considered and the suggested route can bring about a reduction in travel time for the emergency vehicles.

Heavy vehicles like trucks and buses are often slower than other traffic and at traffic signals are not detected as part of a platoon. As a result, they either violate the red light as braking is impossible, or become the first vehicle in the queue, and waste valuable seconds with slow acceleration in the next cycle. Giving balanced priority to these heavy vehicles could improve both traffic efficiency and safety, and could reduce emissions (due to less deceleration, stopping and acceleration).

Granting priority for **public transport vehicles** is common practice in many cities. The advantage of a cooperative solution is that firstly, priority can be granted in a more flexible way (eg it is possible to make changes dependent on the traffic situation or on the schedule of the bus (eg no priority if the bus is ahead of schedule or new lines can easily be introduced and prioritised etc.) and secondly, that the cooperative hardware (RSU, OBU) can be used for other applications as well, thus creating synergies.

Benefits are already seen at low penetration rates; if only public transport vehicles are fitted with the technology at a few key intersections, benefit will already be gained. This group can be extended to include emergency vehicles, trucks and delivery vehicles depending on the local policy goals.

To summarise, the application allows a differentiation of importance of vehicles driving in an urban area. When used for emergency vehicles, it increases safety, especially for road users travelling in conflicting directions.

Requirements

For the Priority Application intersections need to be equipped with cooperative RSU. However, an incremental approach to introduction is feasible.

At central level (in a control centre), an additional software module is required to run the application. This can be installed without major effort or cost.

The Priority Application is a standalone application. It can be – and for reasons of synergies it should be – linked with other applications (eg speed recommendation) but it does not need to be integrated into a package.

Summary: why should investment be made in the application?

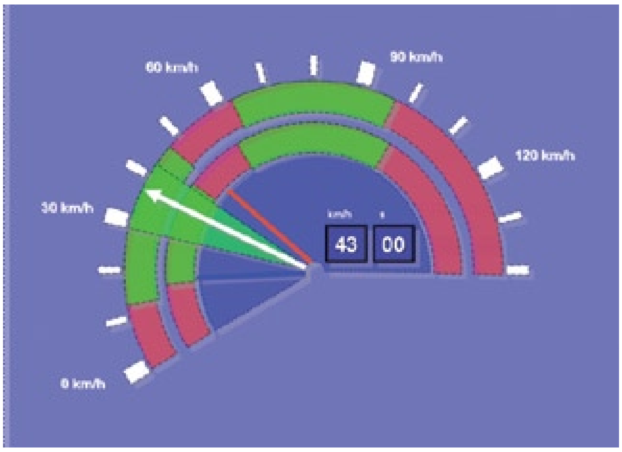
The cooperative Priority Application helps to improve effectiveness of prioritised vehicles, does not require high penetration rates and can be implemented with limited budget and resource input. The cooperative system platform is more robust and reliable compared to existing technology that enables vehicle priority at controlled intersections. The system allows more flexibility to change policies and is scalable both in terms of system penetration and the number of services provided.

Speed Profile

Basic description

The Speed Profile Application consists of recommending a speed or acceleration/deceleration rate to the driver based on their current speed and the state of the network. Signal stage information is implemented by the traffic control system of the city and is communicated to the driver as a speed advisory message. The application aims at smoothing the traffic flow.

HMI: suggested speed and time to green. Source: Thetis



HMI: the suggested speed range for the driver. Source: Thetis

Benefits

An individual vehicle fitted with the application benefits from improved performance in terms of fuel consumption and consequently of pollution emissions. When the penetration rate of the application is higher, the benefit can be extended across the network – for example to create dynamic green waves – which will ultimately improve network efficiency.

The Speed Profile Application works well at a low penetration rate (both at user level and at infrastructure level) and when penetration increases, the benefits also increase. It would be best to identify some key intersections on which to first implement the system, so that a benefit would be felt from the initial deployment of the system. The application demonstrates most promise along urban corridors or entry / exit points of ring roads.

The application itself paves the way to other applications that can further improve emissions and fuel consumption; eg an application which integrates information for hybrid-car-engine optimisation. Additionally, the application can potentially be integrated with navigation functions or dynamic route guidance systems.

In terms of data; the vehicle needs to share location information with the infrastructure. This information can be used by the public authority. Information received within the context of this application will not extend the range of existing information, but it will increase data quality.

Requirements

Existing urban traffic control software used by public authorities should support such an application, and also share information with the vehicle from other intersections.

Deployment can be done in stages, extending the service from corridor to corridor. First deployment can also involve trucks, even if not suited to city centre travel, the freight market can take advantage of the speed profile application on ring road entry / exit points and high speed urban roads.

Summary: Why should investment be made in the application?

In bringing speed recommendations inside the vehicle, this application has good potential in terms of impact on smoothing traffic flow, thus reducing emissions and eventually increasing network efficiency. The average speed will be below the legal speed limits, so the Speed Profile Application is expected to have a positive impact on safety.

Information Application

Basic description

The Information Application supports road managers in the provision of real-time road and traffic conditions to drivers during their trip in an urban or motorway environment. The road manager is able to inform and eventually influence the route decisions of drivers.

The information can be a warning of the current or future position of the vehicle ("incident 2km ahead – slow down to 70") and/or advice (incident A12, 20 min delay – alternative A15 3km ahead). The information is collected through monitoring systems, roadside and/or cooperative vehicles.

Source: Logica

> Warning for vulnerable road users
>
> Within the CVIS project, the Information Application was developed with a focus on informing drivers on incidents like congestion or slippery road stretches ahead. The same application can also be used to warn drivers in residential areas of risks such as pedestrian crossings ("pedestrian crossing ahead – slow down") or school areas in the afternoons when children are going home after school.

Benefits

Drivers are constantly informed of road conditions for their indicated route and, when required, are able to react by – for example – safely reducing driving speed in case of incident ahead or preventing possible rear end collisions; optimise their travel by avoiding congested roads, thus saving time and potentially reducing fuel consumption and emissions.

Existing personal navigation devices do not provide speed advice information according to the real-time road conditions ahead, and are not consistent with traffic information and management strategies of traffic management centres.

Traffic and road managers, local and regional authorities will be able to:

- Support the reduction of road traffic accidents and casualties by information of road conditions ahead, and support prevention of rear-end-collision accidents.
- Support traffic efficiency by aiding drivers in avoiding congested roads through constant access to road conditions in drivers' route and provision of optimised real-time route advice.
- Support fuel efficiency and reduction of vehicle emissions by provision of advice on avoiding congested roads.
- Provide road conditions in real-time to inform drivers quickly and according to their personal route and preferences, and by doing this, prevent accidents and accrue benefit from time savings.
- In the medium-long term (according to market penetration of the application), if life-cycle costs of cooperative application implementation and operation become low enough (and it is clear that they will decrease in price) they could replace existing roadside information systems (used for warning and advice).

On-trip traffic information systems (warning and advice) such as variable message signs are set in a permanent physical location of the road network. The cooperative information application will be available to the driver at any point on the network. Variable message signs provide general information of the conditions ahead which might not be useful to all drivers passing the sign. The Information Application provides personalised information which is adjusted to a driver's route or preferences.

The service can provide some benefits if only one vehicle is participating. All vehicles with this service would provide benefits for the road managers who would be able to provide routing advice and information to all vehicles, thus be able to have a greater degree of managerial control over traffic.

The performance of the Information Application is dependent on the quality of available traffic data. The cooperative concept makes use of both roadside and vehicle (or mobile) based traffic data. The use of cooperative vehicles to provide "floating car data" will significantly increase the availability and quality (and consequently accuracy and reliability) of traffic information. With this information, traffic managers will be able to make more efficient and optimal decisions with respect to traffic management and planning.

The Information Application can be implemented in all road environments. The benefits concerning the rear-end collisions will be higher in highways or rural roads where the current level of availability of real-time information systems is scarce or non-existent. The application provides alternative route advice, and will perform in networks with valid alternative routes without congestion or with competitive alternative travel time / distance.

Requirements

To run the Information Application requires

- access to real-time road network condition information via roadside or vehicle based systems;
- continuous wireless communication from roadside to vehicle (I2V).

The basic concept behind the cooperative applications is interoperability, both technical and content (information) wise. The information application can operate with existing systems such as traffic information sources which are integrated with existing in-car presentation platforms.

The Information Application can run as a standalone application. The benefit of the application can be higher if – for example – cooperative vehicles are operational and utilised as sensor, sender and receiver of traffic and road condition information.

The Information Application could be implemented within a package of applications for reduction of accidents and improvement of traffic efficiency. If a road manager decides to implement on-trip traffic information systems, the cooperative approach should be taken into consideration, and it should be included in a medium-term plan. With existing systems – existing roadside units, and in-vehicle platforms – an incremental introduction is possible and recommended for a transition phase where existing systems are used until the end of their life-cycle. The feasibility and efficiency of this transition can vary from country (and / or region), depending on the existing systems (legacy systems) their function and technical specifications.

Target roads to be implemented are road sections with significant potential for rear-end collision accidents such as: urban highways with commuting traffic or high percentage of freight, recurring peak congested sections (where the location of the end of the traffic jam is unpredictable); and routes for which alternatives are available.

Summary: Why should investment be made in the application?

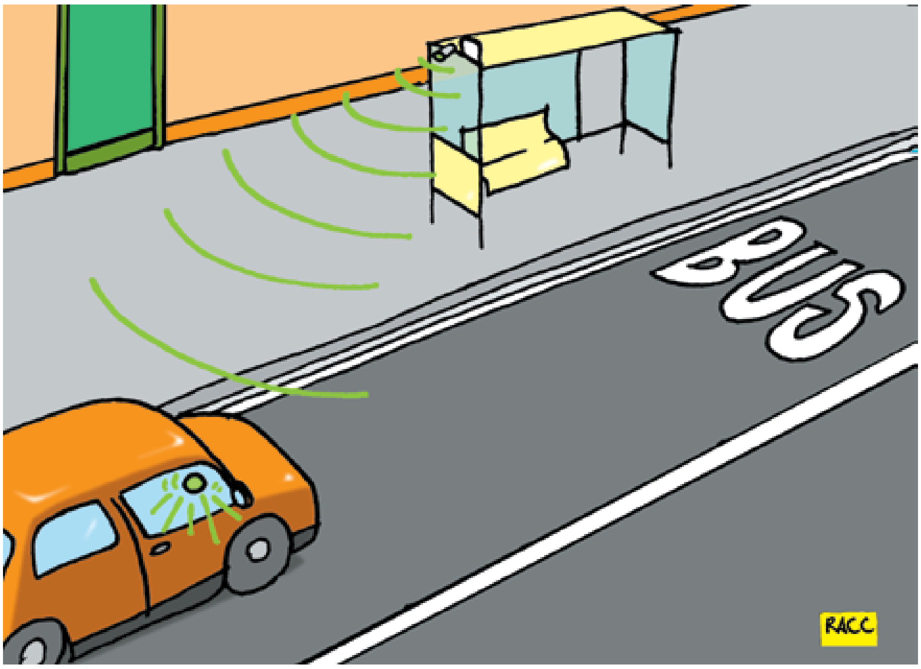
Traffic managers can give personalised information and improve efficiency of the road network with the Information Application. Benefits can be seen for low penetration rates and benefits include more efficient use of existing road infrastructure, safety benefits, reduced congestion and reduced emissions.

Flexible Bus Lane

Basic description

Dedicated lanes or bus lanes for public transport improve the speed of public transport services, but they take up a lot of space, leaving unused capacity in crowded cities. So – in the interest of satisfying other policy objectives – why not share them among some other pre-identified vehicles?

In the CVIS context, vehicles are equipped with an intelligent device that uniquely identifies them and is able to communicate with the roadside infrastructure and also with other vehicles. This cooperative system enables specific vehicles to access a bus lane through a negotiation process that increases the efficiency of the infrastructure by inducing a better traffic flow and reducing the vehicles' travel times to reach their destinations, while ensuring an undisturbed passage of public transport vehicles and preventing delays to journey times.



Flexible Bus Lane Application. Source: CVIS

Benefits

The main objective of this application is to increase the road capacity on certain road sections in urban areas by providing temporary access to bus lanes to selected vehicles, while ensuring an undisturbed passage of public transport vehicles.

Certainly, the usage of reserved bus lanes by certain private vehicle categories can be permitted inline with local traffic management policies. For instance: certain freight companies can be granted access to the bus lanes if they have certain 'green' credentials, in order to encourage environmentally friendly behaviour from freight companies; or car-sharing vehicles could have access to the bus lane if the project is being launched in order to encourage users to try out the system.

It is extremely important that the vehicles entering the bus lane do not detrimentally affect the performance of buses: and this application can only be implemented in certain networks, and on certain bus lanes to ensure that the vehicles do not undermine the performance of buses. Based on simulation studies, there are four factors that affect the success of the Flexible Bus Lane Application:

- Type of the bus lane: a physically separated bus lane is less flexible once traffic has entered the bus lane, compared to a bus lane alongside normal lanes for general traffic, since vehicles can only enter/exit the lane in predefined places.
- Type of bus stops: kerb-side stops have a huge disadvantage over bus bays as the bus lane is fully blocked when the bus halts.
- Traffic situation in the vicinity of the start of the bus lane: traffic lights, right of way rules and the volumes and manoeuvres of traffic flows can influence the delay of vehicles significantly, even before entering the bus lane.
- Traffic situation in the vicinity of the end of the bus lane: traffic lights, right of way rules and the volumes and manoeuvres of traffic flows can influence the delay of general traffic and buses significantly, even after leaving the bus lane.

Benefits in terms of transport efficiency include

- Improvement of the general network performance in the relevant area, along with a reduction in congestion;
- Better use of bus lane capacity, while ensuring an undisturbed passage for buses;
- Selected vehicles from general traffic can avoid traffic congestion by using bus lanes which can decrease travel time dramatically.

Benefits in terms of productivity / economic aspects

- Private vehicles, such as express courier vehicles, may obtain benefits by delivering their goods more efficiently;
- Bus lane investments can be considered more effective by general consent;
- The bus lane access service, if provided not for free, can contribute partly to recoup the bus lane investments.

The application can also provide benefits in terms of other policy areas: the local authority can have control over which sections of general traffic can have access to the bus lane, and this can be steered by other policy objectives in terms of promotion of green vehicles or car-sharing initiatives etc. Indeed, the benefit of the Bus Lane Application is mainly related to the local policy to access the bus lanes in each city and to the specific road network structure of the city.

Based on simulation studies which have taken into account a test case in Bologna (Italy), it seems that this application can show reasonable effects even at low penetration rates, even if its effectiveness is very dependent on the road network, the type of the bus lane and the typical traffic situation in the vicinity.

The application is relevant for medium/big cities where the presence of bus lanes is an integral element of urban mobility.

Requirements

There are certain requirements for the flexible bus lane application:

- For each section of bus lane only one cooperative roadside unit is necessary;
- Public transport vehicles must be equipped with an AVM (Automatic Vehicle Monitoring) system in order to know the position of buses and the estimated times of approaching the bus lane(s) in real-time;
- There must be a video enforcement system to make sure only licensed vehicles access the bus lane;
- In addition, a traffic monitoring system / traffic light detector would be beneficial.

The application may interface with legacy systems mentioned above (AVM, Video enforcement and Traffic monitoring systems), but it can also interoperate with other systems, such as traffic signal controllers, to manage possible green-waves in a more effective way.

The cost of flexible bus lane system is marginal if the city has already adopted the following infrastructures related to traffic management:

- public transport monitoring system (AVM);
- communication infrastructure (although at the moment in many countries IPv6 is not available / active (see Part III of this document for more about IPv6));
- video enforcement system;
- traffic monitoring system.

Summary: Why should investment be made in the application?

This application can be used to prioritise certain types of vehicles – depending on local policy goals – in often congested areas of the city by better using existing road space without compromising public transport.

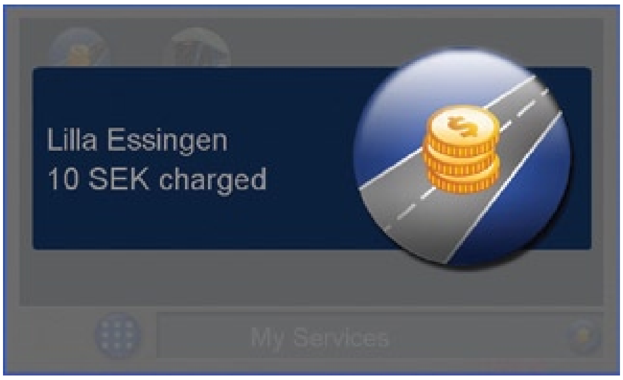
The bus lane can be used to promote other policy objectives, such as car sharing. Source: Frank Vincentz, Wikimedia Commons

Tolling

Electronic toll collection (ETC) is an area which has not been addressed with an application in the CVIS project, but it is an area which could heavily benefit from cooperative systems applications. With the European Commission Decision of the 6th October 2009 on the European Electronic Toll Service, there is the requirement of interoperability of the toll collection services within the Community. Although toll collection services based on wireless communications may already exist within Europe, the guarantee of interoperability of services is not satisfied, and if the ETC systems were applications based on a common platform (such as CVIS), then this interoperability could be more easily guaranteed.

There are several technologies available for tolling, as well as different types of tolling (distance based charging (as proposed in the Netherlands), area based charging (in existence in London), and cordon charging (in existence in Stockholm)). The different forms of communication for the tolling are: GPS/GNSS, DSRC both with and without automatic number plate recognition (ANPR) technology. Both GPS/GNSS and DSRC can conceivably be integrated within a cooperative systems platform to enable electronic toll collection.

Cooperative OBUs and RSUs can be used for tolling procedures and no additional hardware would be necessary. The respective applications could easily be uploaded to the OBU when necessary: this would entail a minimum of political effort for standardisation and no specific regulation for cross-border applications since the application specific for one tolling area would be uploaded once the vehicle passes into the area.



Screenshot from a tolling application. Source: CVIS

Screenshot from a tolling application. Source: Logica

Road Safety

In terms of road safety, the ultimate aims are to reduce accidents and casualties on the roads. Over the years, this has been achieved through targeted behavioural campaigns regarding seatbelt use, and alcohol consumption, as well as enhancements of road infrastructure and in-vehicle technologies. The CVIS project did not focus on safety issues, since this was considered in another EU project called SAFESPOT which met the strong runtime requirements demanded by safety-critical applications. The following two applications are taken from the SAFESPOT project, however the CVIS and SAFESPOT technology is interoperable.

Road intersection safety

Basic description

Road Intersection Safety prevents accidents or reduces the impact of accidents at intersections. This is done with V2V communications. Thus, local authorities cannot directly influence the deployment of this application. It is included in this document to give a comprehensive overview on the potential benefits of cooperative systems to achieve local transport policy goals.

The SAFESPOT project has identified six safety-related issues at intersections: accident at intersections; obstructed view at intersection; permission denial to go-ahead; defective traffic signs; other vehicles braking hard due to red light; and approaching emergency vehicle warning. The intersection safety application addresses each of these cases.

Benefits

This application meets the safety objective to reduce accidents and casualties on the road. Today, intersections are still a major cause of accidents and cooperative systems provide novel measures that specifically target accident reduction at intersections. Cooperative systems and their ability to "communication around the corner" address safety at intersections very well, reducing overall accidents and fatalities on Europe's roads.

The Road Intersection Safety application provides benefits if run as a standalone application, but due to the very nature of the underlying technology, it makes more sense to add other safety applications, since they increase the benefit to the driver without increasing cost greatly.

In vehicle technology, only cooperative systems are designed to specifically address road traffic accidents at intersections. Therefore, cooperative systems give a big benefit if combined with other systems such as Electronic Stability Control or environmental sensor based systems: cooperative systems add 'mouth and ears' (communication) to a vehicle which today only has 'vision' (camera, radar) and 'touch' (vehicle state sensors) senses.

In order to achieve significant benefits, the Road Intersection Safety application needs a high market penetration rate.

Requirements

Road intersection safety can be built on vehicle information alone: this means that the vehicles need to be equipped with communication systems and safety systems. If some infrastructure is also equipped, the system performance can be increased at some intersections, but this is not the case for all intersections and is therefore not mandatory.

Summary: Why should investment be made in the application?

Safety at intersections can only be increased by cooperative systems. Since the number of fatalities and accidents is still high at intersections, Road Intersection Safety is a worthwhile application which although it requires a high penetration rate for individual vehicles, requires little to no investment for local authorities, and can lead to considerable safety benefits.

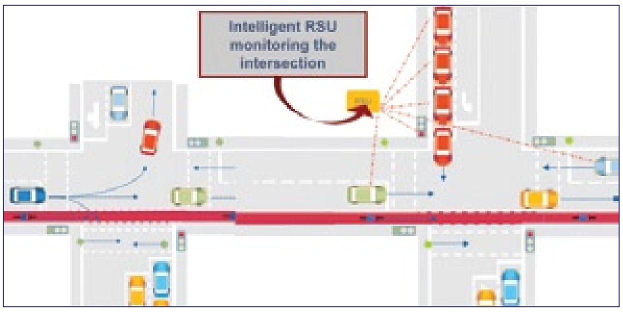
Safety at intersections can be improved by cooperative systems.
Source: Peek Traffic

IRIS - Intelligent Cooperative Intersection Safety System

Basic description

The infrastructure-based application "Intelligent CoopeRative Intersection Safety System" (IRIS) monitors an urban intersection to reduce the number of accidents. In order to achieve the objective of a safe urban intersection with significantly fewer accidents, it is necessary to detect critical situations as early as possible and to monitor the whole intersection including its approaches and exits. Information provided by cooperative vehicles approaching the intersection has to be fused with data obtained from roadside sensor systems and to be stored in the Local Dynamic Map (LDM). The LDM is a real-time or near real-time geometric representation of relevant infrastructure and non-infrastructure features and objects in the vicinity of the RSU. Based on the available data in the LDM, the application calculates the exact trajectories of the vehicles. Furthermore, an extrapolation of the trajectories is computed that can be regarded as a forecast of the road user movements. By analysing these trajectories critical situations can be identified and drivers can be warned in time.

The IRIS prototype developed during the SAFESPOT project has the aim to identify potential red light violators, to support the drivers turning right in being aware of pedestrians and cyclists as well as to assist unprotected left turning vehicles without a separate green light.



IRIS Application. Source: SAFESPOT

Benefits

The main benefit is the protection of vulnerable road users, which are detected in the case of SAFESPOT by laser scanners. But other already existing detection systems for pedestrians and cyclists can be used, too. Furthermore, the protection against red light violators and information on approaching emergency vehicles can be provided. In addition, the gathered information on the positions and manoeuvres of the vehicles can be provided to the local traffic control.

The main benefits of this application are in terms of safety: in direct terms, in reducing accidents and casualties on the roads. One could see that the traffic signals at the intersection are enough to assure a safe crossing and turning at the intersections, but there are still a lot of situations in which the driver has to be aware of other extraneous issues and not only to look at the traffic signals: eg a cyclist is unprotected against a right turning vehicle. This is the major benefit of the IRIS System.

In addition, it should be mentioned that compared to intersection monitoring systems which are based only on the communication between vehicles (V2V communication), the IRIS system has several advantages. IRIS is able to broadcast the traffic signal status and is able to provide data (gathered from the cooperative vehicles) to the local and network-wide traffic control. This information is not retained if the vehicles just cooperate between themselves. In addition, the risk of occlusion is quite minimal in the IRIS case. The approaching vehicles will communicate with the RSU relatively early on, and can exchange data, whereas the direct communication between two approaching vehicles might be blocked by buildings.

In addition, the application will also benefit traffic management by increasing the volume and quality of traffic data. The major opportunity is that public authorities are able to acquire processed data on the manoeuvres of the vehicles which can easily be used for estimating the local traffic situation. This can act as a valuable input for the estimation of the traffic state in the city or for local traffic control.

The penetration rate of the equipped vehicles needed in order to perceive benefit depends on the rate of already equipped urban intersections (i.e. those which have existing detections systems which are able to track road users). There is a distinction between the penetration rate needed for equipped intersections and equipped vehicles: in the first phase of rolling out the system, only intersections with high accident rates should be equipped, and every equipped vehicle passing the intersection would benefit from the system. In the beginning, this might only be a few, but in the long-term more and more vehicles will be equipped.

Requirements

A detection system for vulnerable road users is needed. The system needs to be connected to the traffic light controller.

In the case of SAFESPOT, laser scanners were used. The price of the laser scanners will decrease in the future, because the supplier plans to step into the market and start with mass production of the scanning system. Cheaper detection systems such as cameras could be used as well. Already-existing detection systems are included in the data fusion process, and a detailed static description of the intersection is needed.

The infrastructure can be introduced incrementally; for example, only the communication unit and the link to the traffic signal control can be established to start with. With this setup, the movement of vehicles can be monitored and the status of the traffic signal can be broadcast. In the next step, the intersection can be equipped with the detection systems for vulnerable road users

Summary: Why should investment be made in the application?

IRIS and its modules provide an opportunity to increase the safety at intersections in particular for vulnerable road users and in parallel use the data gathered for an enhanced traffic monitoring and control system. The application can be rolled out on an intersection by intersection basis.

Other safety applications

There are many other safety applications that can be integrated into a cooperative systems platform. One such example is an Intelligent Speed Adaptation (ISA) application which brings speed limit information onboard the vehicle. Navigation devices in the vehicle (typically GPS or GPS enhanced with additional information) give a precise location and heading, whilst an onboard map database compares the vehicle speed with the location's known speed limit. What is then done with this information varies from informing the driver of the limit (advisory ISA), warning them when they are driving faster than the limit (supportive ISA) or actively aiding the driver to abide by the limit (intervening ISA). All intervening ISA systems that are currently being used in trials or deployment can be overridden.

Other safety applications which can be integrated within a cooperative systems platform include eCall, Lane Change Assist, Lane Keeping Support, Local Danger Warning, etc. Many of the safety applications are more relevant to interurban than urban roads.

Freight management

Freight is imperative to the smooth running of any city, but the relationship between freight operators and local authorities is not always a smooth one. Freight includes small, medium and large vehicles, which need to deliver goods at all times of day to all parts of a city. Aims in terms of freight management are to follow regulations (with respect to loading and unloading, weight, emissions, and entering certain areas), improve vehicle km efficiency and to improve urban freight data management.

Besides the applications described in this section – dangerous goods management, loading bay and parking zone management, and access control management – other applications as described before are relevant for freight transport: eg the intelligent intersection safety system, or priority application.

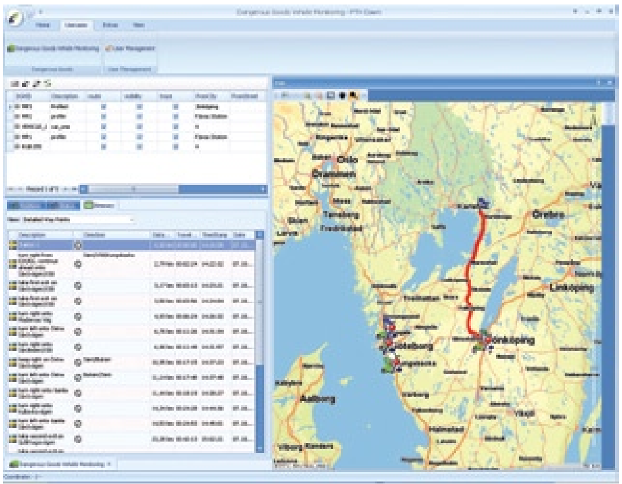
Dangerous Goods Management

Basic description

The Dangerous Goods Application focuses on a goods vehicle that delivers dangerous goods to a specific location. Before starting its journey, the dangerous goods vehicle has to register at the traffic management centre in charge.

This traffic management centre is responsible for the calculation of the allowed route for the vehicle. The routing engine at the traffic management centre uses special truck attributes included in specialised maps to ensure that the dangerous goods vehicle travels on approved roads at all times. The traffic supervisor (within the traffic management centre) can edit this dangerous goods map. She can open or close a certain road link thereby actively influencing the routing engine, and manipulating the route choice (on the permissible route map) as well as setting local traffic restrictions. If the traffic supervisor does not want the dangerous goods vehicle to journey on a particular road, she can start the re-routing by opening or closing road links in the map. The new route is immediately transferred to the vehicle's client to provide the driver with the updated information.

The traffic supervisor can monitor the dangerous goods vehicle to ensure that the vehicle does not stray from the pre-planned route. Real-time traffic information is fed into the system and when the situation requires it, the vehicle is automatically re-routed.



Dangerous Goods Application: vehicle tracking software. Source: PTV

Different user groups such as fleet operators, police and health services can access the monitoring system to view the dangerous goods vehicles. Obviously each user group has different permissions that limit access to information, for example:

- The traffic supervisor can view every dangerous goods vehicle in her area;
- The fleet operator is only allowed to view vehicles in their fleet;
- The public authorities such as the police authorities can only view the dangerous goods vehicles in their area of authority.

Benefits

The application can be used to plan safe routes for dangerous goods vehicles, eg avoiding sensitive areas such as near schools. The traffic management centre is aware of the different hazardous goods of the different dangerous goods vehicles in their area of authority. Therefore a potentially dangerous "vehicle mix" can be prevented, for example in critical road stretches such as in tunnels.

Local and regional authorities can benefit from the application by using the monitoring client to identify dangerous goods vehicles in their region at any time. In case of an accident, the health services and other authorities can react faster and more efficiently since information on dangerous goods materials and dangerous goods vehicles involved in the accident are readily available.

Traffic supervisors can use the tool to instantly re-route a registered dangerous goods vehicle on an as-needed basis, or to limit access to roads for a certain timeframe (for example, to avoid additional, temporary, external risk factors). An example of why this might be required is when a big sports event takes place in a city; this requires dangerous goods vehicles to avoid a certain area for a specific timeframe, whereas at other times the possibility to use a particular area or route is not limited.

A comparable system is not used at the moment.

Requirements

This application can be run as a standalone application. The user needs a Windows capable PC (with a Microsoft .net 2.0 environment) in the traffic management centre and a mobile client (i.e. an OBU) in the vehicle. The monitoring client and the RoadEditor need to be installed on the PC in the traffic management centre. The monitoring client can be downloaded via the internet.

Local authorities can implement the hardware and software environment with minimal effort: no RSUs are required to be installed. To make the application useable in a reasonable way, it is necessary to fully involve the traffic management centre. To ensure that dangerous goods vehicles are monitored during the entire journey requires traffic management centres that are responsible for a particular area to work cooperatively which they do not currently do. In many cases, additional traffic management centres would have to be established. One traffic management centre can cover a bigger region with more than one city. Smaller cities that cannot afford to implement an independent traffic management centre can merge with other cities and/or villages. Additionally, communication and cooperation of existing traffic management centres have to be improved and standardised.

The fleet operator can use the system in combination with her "regular" fleet software. Fleet operators have to accept that the routing of their dangerous goods vehicles will be in the hands of the traffic management centre – and not the fleet operator – in some situations.

Summary: Why should investment be made in the application?

The application offers advantages to traffic management centres and local authorities as it provides information about the number of dangerous goods vehicles in a certain area as well as the position of the registered dangerous goods vehicles and their loads which can be illustrated on a monitoring map: for each vehicle information about the loaded hazardous materials and also driver information are given. This enables easier, more detailed risk assessments which in return will improve safety during the transportation of dangerous goods.

In case of an incident or accident, the dangerous goods vehicle can be rerouted or the local authorities can react in an appropriate way.

The Dangerous Goods Application allows tracking of dangerous goods. Source: Jens Hirschfeld, Wikimedia Commons

Loading Bay and Parking Zone Management

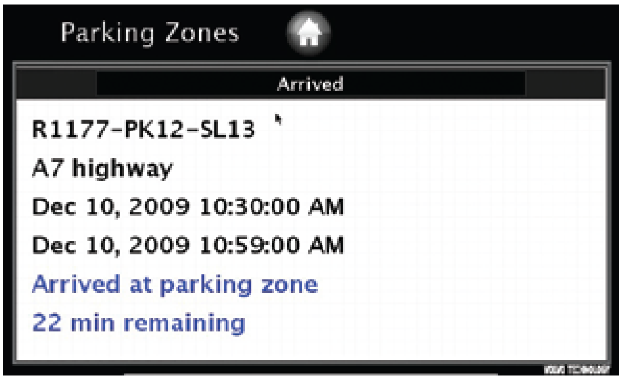
Basic description

On-street loading and unloading activities often hinder traffic flow considerably. Many cities have established designated loading areas and have restricted on-street stopping facilities. If the loading bay is blocked, an arriving freight vehicle will need to make a diversion around the neighbourhood until the bay is empty again. This causes extra fuel consumption, emissions, and costs for the freight operator.

On highways, parking areas for HGVs are limited and this often cause problems for drivers and fleet operators if drivers are obliged to rest but cannot find a parking space.

On highways, parking zones for HGVs are limited and this often causes problems for drivers and fleet operators if drivers are obliged to rest but cannot find a parking space.

The Loading Bay and Parking Zone Management Application allows fleet operators/drivers to book the loading bay or parking space in advance which will reduce unnecessary vehicle km and increase comfort for drivers. Local authorities gain a monitoring tool for parking and delivery activities that provides data for better planning of loading bays and parking zones, and eventually access restrictions for HGVs in certain areas or at certain times.



Source: Volvo Technology Corporation

Benefits

This application allows for a smoother use of loading bays in urban areas. Through allocation of time slots to designated vehicles, unnecessary vehicle km of freight vehicles waiting for the loading bay can be reduced. Thus, air pollutant and noise emissions are reduced as well.

The Parking Zone Application will allow for flexible and dynamic parking policies and local restrictions as well as for more efficient use of existing parking spaces. Congestion will be reduced due to there being fewer vehicles in the neighbourhood at the same time, and waiting time for parking will also be reduced.

Freight operators benefit from less unnecessary vehicle km, faster deliveries, and possibility for better planning long distance trips that include mandatory resting times (on highways).

The current system for managing parking is basically a combination of road signs specifying the allowed stopping time and accompanying enforcement policies. The parking zone application allows for greater flexibility when it comes to setting allocated slot times, as well as a more automatic way to detect unwanted behaviour. However, the parking zone application also requires a dedicated level of enforcement, otherwise the system will not be totally successful.

The benefits can be gained as soon as one vehicle starts using the system. However, low market penetration could mean that the parking spaces are left unused due to few users. A solution to this problem is to allow non-system users to use the parking spaces during periods of lower traffic demand.

By using the parking zone system together with a camera, the level of use of the parking area and the number of conflicts that have occurred can be measured. With this information, new parking areas can be more accurately designed, more accurately based on actual use rather than on estimated use.

The application is relevant to all types of areas where you have a large number of incoming deliveries, such as shopping streets, terminals etc.

Requirements

The parking zone applications consist of four sub-systems: an in-vehicle application for handling parking bay reservations, a roadside unit application for the handling of the loading bay/parking zone (departures, arrivals etc.), a parking zone operator back-office system and a fleet operator back-office system.

The deployment can be made stepwise if you start with one parking zone and let the system expand with the number of users.

There might be legal or liability issues if the system is used as an enforcement tool: this is an issue that should be considered.

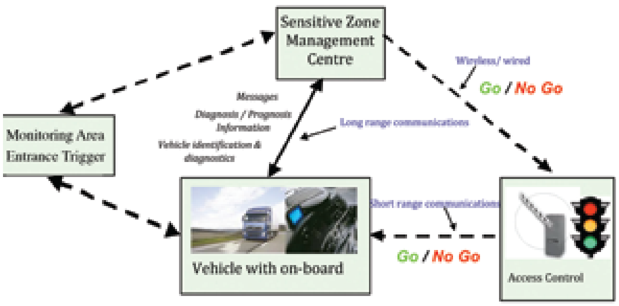
Summary: Why should investment be made in the application?

By using the parking space application, deliveries will be easier to plan and more efficient, and traffic planners can optimise the use of existing parking space while reducing local congestion.

Access Control Management

Basic description

The basic idea of the Access Control Management Application is to monitor vehicles approaching sensitive zones in order to allow/deny the access, as a preventive safety measure to avoid accidents and as a tool to dynamically control traffic conditions in restricted areas. The idea is that the vehicles have an "always-on" seamless communication with infrastructure so that the road operator is aware that they are approaching. The road operator defines rules associated with a certain sensitive area on a web interface. Vehicle information (type, dimensions, etc) is used to assess the access control rule. The driver is notified on his HMI about allowed or denied access. The application is designed with freight vehicles in mind, although could foreseeably be extended to include other vehicle types, eg to control urban environmental zones



Access Control Management Application.
Source: Volvo Technology Corporation

Source: Volvo Technology Corporation

Benefits

Local authorities will be able to monitor freight vehicles entering restricted areas more easily and obtain the benefits that these restricted zones are designed to achieve. Restricted areas can be defined as sensitive for environmental reasons, for safety reasons, or in terms of high congestion rates.

In terms of traffic management, an obvious benefit is in terms of reduced congestion. Congestion is very often a problem associated with peak hour traffic flows rather than due to inadequate capacity, and this application could help to increase traffic fluidity by defining specific policies for freight transport accessing certain areas at certain times.

The benefits start as soon as one vehicle starts using the system, however market penetration needs to be quite extensive in order to allow a great number of vehicles to be monitored, and for a significant benefit to be felt. An approach to this problem could be that vehicles using the access control application receive priority over non-users, and also the possibility to access areas during times when they are normally closed.

The application is relevant to all types of urban environment.

Requirements

The entrance roads to the restricted area need to be equipped with cooperative RSU. In addition, a second wider ring of RSU is recommended in order to communicate re-routing suggestions early enough to vehicles with denied access.

Summary: Why should investment be made in the application?

This application provides a benefit to public authorities in terms of monitoring and enforcing restriction zone policies: providing benefits in terms of safety, congestion reduction, and environmental benefits.

Public transport

With respect to public transport, the major aims are to achieve a high quality public transport network that is fast, reliable and easy to use. There are many examples of how wireless technology can benefit public transport: real-time travel information (RTTI), automatic vehicle identification or priority for public transport at junctions to name but a few.

These applications already exist as standalone applications, and – except for a mention in the priority application – applications with the purpose to benefit public transport have not been not considered within the CVIS platform.

What then, can be seen as the added value of using the CVIS or another cooperative systems platform to run these applications?

The major problem with the existing standalone applications lies in their inflexibility; these applications are designed to solve one problem, and they are dependent on specific communications technology and hardware. Technology is moving forward quickly, and existing technologies will soon become obsolete. Additionally, the two-way communication of next generation cooperative systems technology allows the driver to receive communication from the roadside infrastructure as well as to send communications.

Building applications within an open platform (such as CVIS) which can be easily upgraded to allow changes in communication media and hardware (and thus also changes in policies) creates more flexibility and ease of use of the application.

There is the possibility that existing priority or RTTI applications can be upgraded to become part of a cooperative platform, so that existing solutions can run until the end of their lifecycle; this can reduce costs, and public authorities and public transport operators can reap the benefits of investments already made.

Environmental impacts of transport

Measures required to reduce the environmental impacts of transport include reducing air pollutant emissions, keeping traffic out of sensitive areas, maintaining access restriction zones, and reducing noise. There have been several applications in this chapter that mention the environmental benefits arising from cooperative systems; this has often been due to better network management, so reduced time spent by vehicles on the road and reduced emissions.

An example is that of loading / parking bay booking which reduces detours and illegal parking. Simulation studies show impacts of the parking bay booking on the freight vehicles themselves, and on other vehicles, and show that contention rates for parking will decrease. This will mean direct reduction in emissions, but there will also be reduction in emissions from freight vehicles which make detours to arrive later.

Additionally, the Access Control Management Application provides an application that prevents freight vehicles from entering sensitive areas and could eventually also be used to manage low-emission /environmental zones. Other applications designed along the same lines would have the same benefits.

There are indirect benefits for the environment from most of the applications which have a direct effect on road network management. This of course comes with a caveat: as long as the roads are not so congested that the applications cannot make a difference, there should be a benefit for the environment as well as for road network management.

Interview

Jean-Charles Pandazis, Head of Sector EcoMobility, Ertico

How do cooperative systems tackle urban transport challenges?

Reducing the environmental impact of transport in urban areas is key area, and there is increasing political will to reduce emissions in urban transport. Cooperative systems offer many possible services to reduce the environmental impact of urban transport including: priority at intersections for trucks (to reduce stop-and-start driving behaviour which causes more emissions than continuous traffic flow); delivery space booking for trucks (which, for example, reduces the need for trucks to circle around the block while waiting for delivery spaces); routing applications which provide information on the best available route with respect to emissions; etc. Cooperative systems also provide possibilities coupled with electric vehicles, to further reduce overall emissions.

Cooperative systems allow for the possibility to be able to integrate all different mobility services, allowing a road user to choose the best way to travel (also in an environmentally friendly way). Cooperative systems allow the possibility of managing data in a new way (with FCD), but also of predicting the evolution of the system to better manage models and policy in the future. CVIS has built a firm basis, and other projects will build on this in the future (particularly the environmental aspects of cooperative systems).

How do cooperative systems fit into an overall traffic management / ITS strategy?

The benefit for traffic management (particularly public transport) is huge, because of the real-time picture that can be taken of the network. Cooperative systems allow us to change the way we look at mobility because of the new communication and data possibilities.

Cooperative systems are completely inline with ITS strategy, and the European Commission's ITS Action Plan (particularly Action 4: cooperative systems are the basis for this, and CVIS is the answer to this).

What are the major challenges to deployment?

There are many actors involved in the deployment, and a major challenge is not getting into a 'chicken and egg' dilemma with respect to who takes the first step: those who should put the infrastructure in place may be waiting for the vehicles, and those constructing the in-vehicle components may be waiting for the infrastructure… In order to avoid this, standardisation needs to be in place, and all stakeholders need to understand the advantages and benefits of the systems. Addressing user acceptance issues such as data privacy is also another key issue.

What is your vision for cooperative systems?

My vision of cooperative systems is of a completely integrated transport system – not just on the road – where all actors are connected and exchanging data and offering services to each other.

> “My vision of cooperative systems is of a completely integrated transport system.”

Part III Cooperative Systems: What is needed to make it happen?

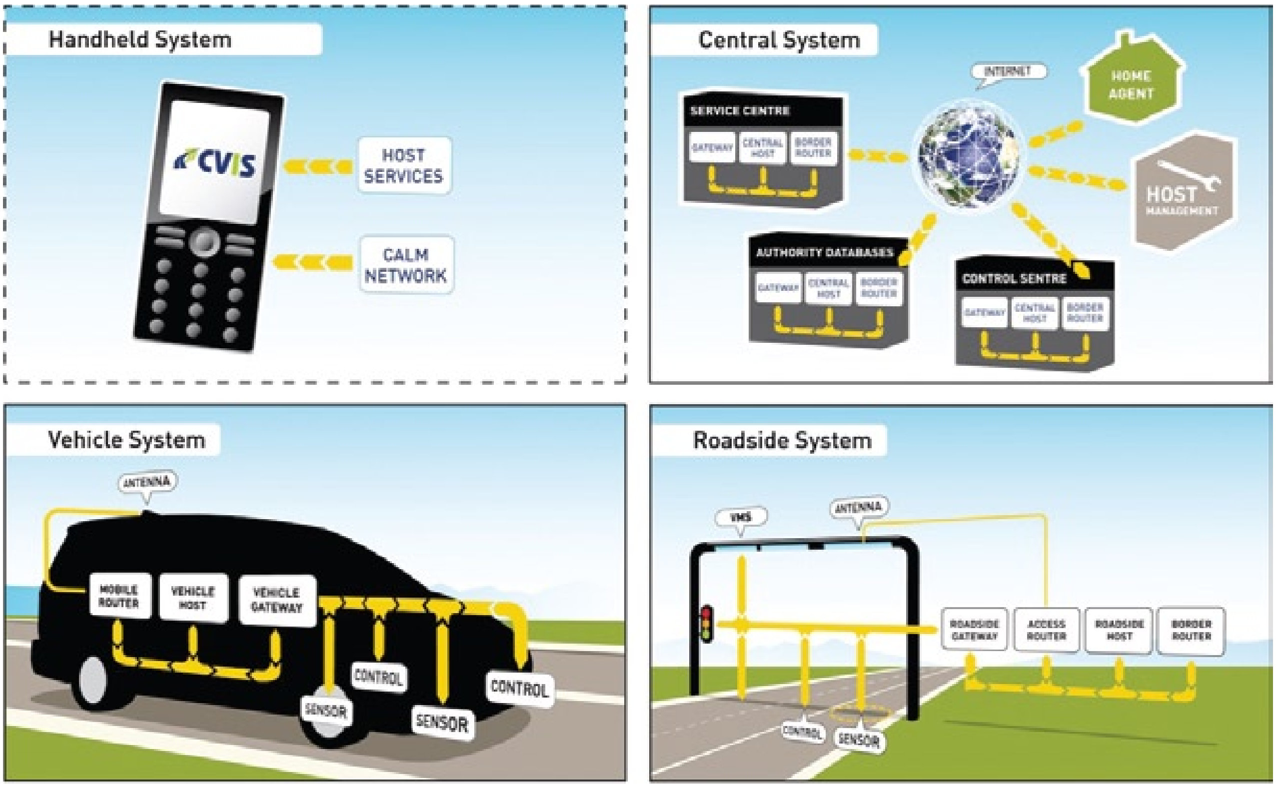
This chapter surveys the technological aspects of cooperative systems: the equipment needed; communication infrastructure, standards, and architecture; and internet protocols. Additionally, costs and business models are looked at.

Source: Q-Free

Technology

Introduction

As was seen in Part II, as long as the basic CVIS infrastructure is installed, running applications can be quite cheap and easy, and can even be introduced step by step to run alongside or replace legacy systems. This section will look at what this basic CVIS infrastructure is, and what is involved in installing it in urban areas. The figure below shows the basic components involved in the CVIS system: a vehicle, a roadside unit, a control centre, and a handheld unit (although the handheld unit is not a necessary part of the system). These components are all linked through external communications through which the roadside system, the vehicle system and the control centre will be connected over the public internet using IPv6 (or IPv4) networks.



Components of the CVIS system. Source: CVIS

All components of the system include hosts, routers and gateways:

- A **host** provides the execution environment where the CVIS applications and facilities are hosted (deployed and executed). The CVIS execution environment is based on Java (an object-oriented programming language) and OSGi (open services gateway initiative).
- A **router** provides access to the communication infrastructure enabling connections between different CVIS hosts.
- A **gateway** is a protocol converter and firewall between the open and the proprietary part of a subsystem: its purpose is to protect the technical infrastructure of the existing subsystem (vehicle, roadside or control centre).

In terms of hardware, the two main issues that need to be considered by local authorities are: roadside units and setting up the control centre. For a basic roadside unit, this requires a router and an antenna (with a host and a gateway as described) ie the ability to receive and send information as well as to process it. In the figure above, the RSU also has a sensor, although this is already a more advanced version.

It is important to note that CVIS roadside units can be converted – and indeed work alongside – existing roadside units. The number of RSUs required needs to be defined on a case-by-case basis for each network. It depends on several factors:

- The network in question;
- The application(s) that is/are foreseen;
- The legacy systems that are in place;
- The communication media that are used (see next section on CALM).

It is likely that when cooperative systems are deployed, they will be deployed step-wise: with high gain applications being deployed before widespread cooperative systems become a reality. A possible deployment scenario for cooperative systems could be[3]:

1. Penetration-independent applications eg Priority Application only installed along a problematic stretch of road.
2. A few equipped vehicles on the roads used to evaluate state of traffic and environment eg vehicles contain equipment with capability to gather data about pollution and state of traffic flow.
3. Local support to drivers (warning, traffic, environment) eg SAFESPOT applications, Information Application.
4. Cooperation with adaptive traffic control eg Strategic Routing Application.
5. Building up of car-to-car networks in order to allow full communication capability to fully support – for example – safety applications.
6. Self-organisation of traffic flow (complete system inter-connection).

This is being mentioned here in the discussion of what hardware is needed for cooperative systems in order to make the point that full roll-out of cooperative systems is not expected right from the beginning. It is clear that in the beginning, deployment must be made with quick-win solutions. For a local authority, the quick-win solution may be to include the Priority Application: if the Priority Application is first introduced over a particularly problematic stretch of road with several junctions, then the local authority is required only to equip a few junctions, and thus only to provide a few roadside units. The vehicles which are to gain priority must install the equipment on board. This might be the quick-win solution for a local authority, but it is important also to note that the quick-win solution would be different for other stakeholders such as fleet managers.

Example of CVIS Roadside Unit.
Source: CVIS

The CVIS in-vehicle equipment has become more sophisticated yet smaller over the course of the project. The in-vehicle component of CVIS 1.0 was bulky, as shown with these pictures from the in-vehicle components from the CVIS trial which took place in London.

In-vehicle components & close up of CVIS OBU (a PC) used in CVIS trial in London. Source: Transport for London

In CVIS 1.1, the PCs are gone, applications and services run inside a touch-screen PC but the functionality remains the same. CVIS 1.1 is demonstrated below:


CVIS 1.1: Antenna & Touch Screen PC. Source: Q-Free

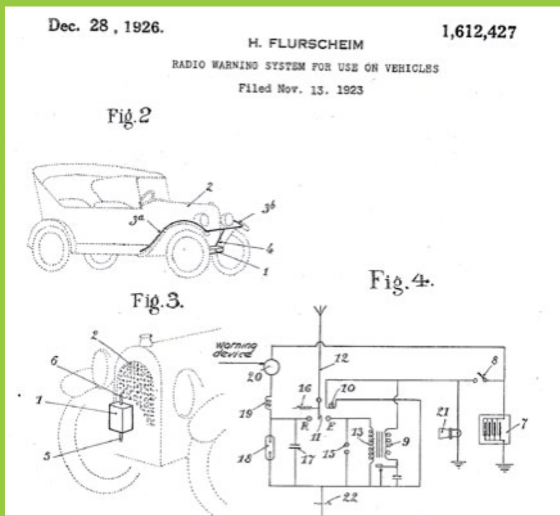
The same is happening with the hardware for the RSUs: it is becoming smaller and sleeker, while retaining the same functionalities as its bulkier precedents.

The CVIS platform is designed in such a way that once the basic roadside equipment is installed, it can be used for many applications. So even though it may be installed on a stretch of road in order to create priorities for certain specific vehicles, other applications can be installed afterwards. This is not the case for existing priority technology which is designed only to solve one problem.

If the first low penetration rate applications are successful, then further CVIS roadside units can be installed. This is dependent on what local authorities require from the cooperative systems technology: there is not a one-size-fits-all to deployment; this depends on the local transport plans of the authority, and what other measures they already have in place.

A control centre is also required by the local authority: this consists in its most basic form of a control host and a router (a computer, and someone to maintain it), and could be integrated into any existing traffic control centre. Obviously if there is widespread roll-out of cooperative systems, then the control centre will require considerable effort in terms of manpower and maintenance.

Cooperative systems: a new technology, but not a new idea! A patent was filed in 1926 by the American Harry Flurscheim. An excerpt from the patent reads: “The present invention relates to radio warning systems for use on vehicles intended to permit a vehicle to signal its presence by means of electric waves to other vehicles in its more or less immediate vicinity, equipped with similar or equivalent apparatus and devices, particularly to such vehicles located in front or on the side of the vehicle signalling its presence and facing in the approximate direction of said signalling vehicle.” Of course, modern technology has moved on quite a way from this…



CALM standards

Communication is obviously a key part of the cooperative systems technology. At the heart of the CVIS platform is a mobile router based on the CALM (Communications Architecture for Land Mobile environment - www.calm.hu) standards for vehicle communications. CALM is an initiative hosted by the International Standards Organisation (ISO) to define a set of wireless protocols and parameters for medium and long-range, high-speed ITS communication across a variety of methods of transmission.

The scope of CALM is to provide a standardised set of air interface protocols and parameters for short and medium range, high speed ITS communication using one or more of several media. The communication protocols form the foundations necessary for cooperative vehicles technology. CALM aims to create a continuous communication link, independent of the type of media used.

The CALM communication service includes the following communication modes:

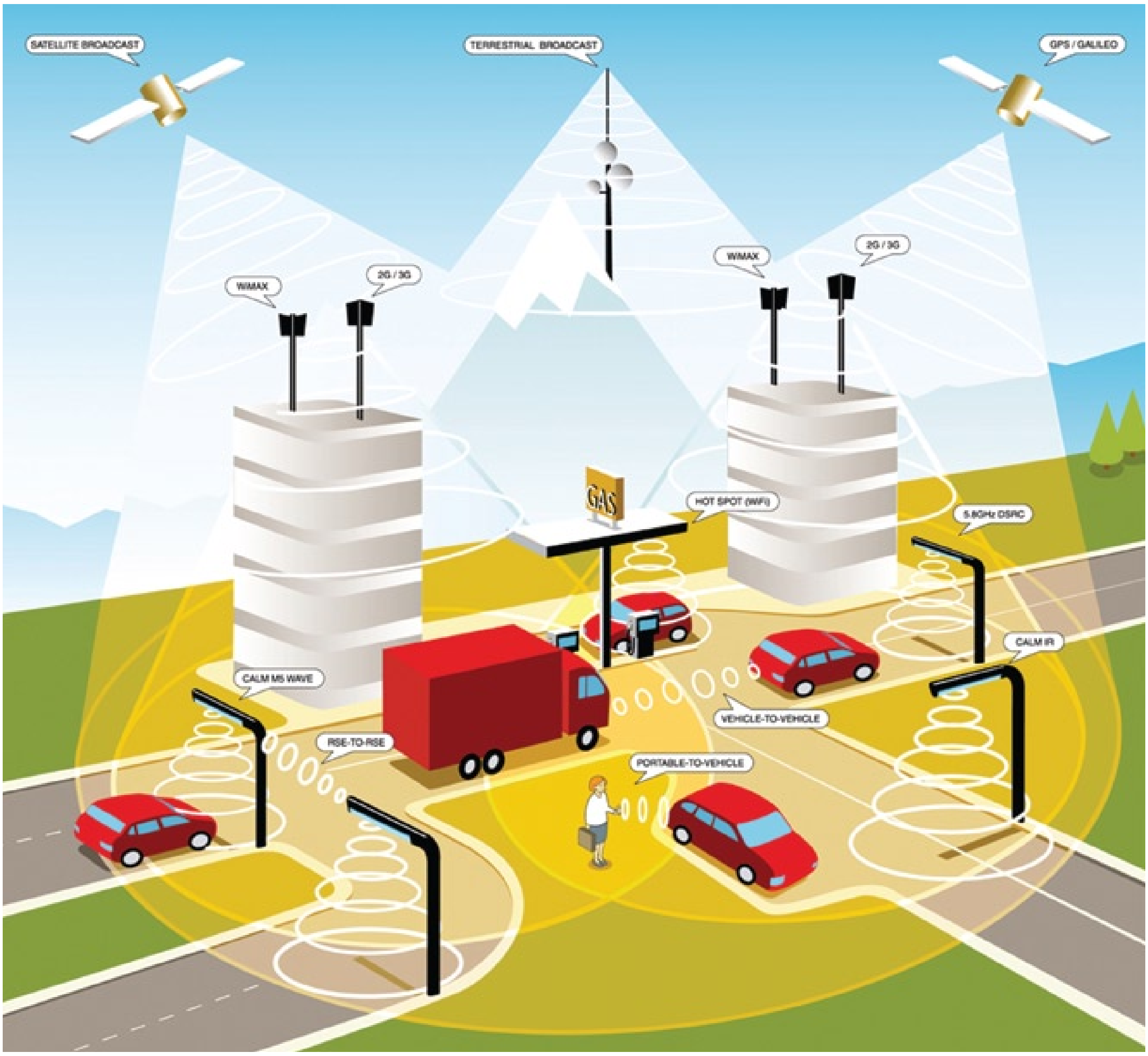
- Cellular systems, e.g. GSM/GPRS and 3G;
- Infrared communication;
- Wireless LAN systems based on IEEE 802.11a/p;
- 5.9GHz Dedicated Short-Range Communications (DSRC).

The CVIS vehicle router will continuously optimise the choice between the different media dependent on signal strength, price, directivity, etc. The needs for CVIS in terms of communication depends on the application in question: for example, the Information Application requires continuous connectivity, whereas the Priority Application requires connectivity only when approaching a junction, and a safety application requires faster communication than a routing application.

An overview of the CALM communication media (and the media used by cooperative systems technologies) is given in the figure on the following page.

CVIS includes the following communication modes for cooperative systems:

- Vehicle to Infrastructure: multipoint communication parameters are automatically negotiated, and subsequent communication may be initiated by either roadside or vehicle.
- Infrastructure to Infrastructure: the communication system may also be used to link fixed points where traditional cabling is undesirable.
- Vehicle to Vehicle: a peer-peer network with the capability to carry safety related data such as collision avoidance, and other vehicle-vehicle services such as ad-hoc networks linking multiple vehicles.



Overview of CALM standard and CVIS. Source: Q-Free

Internet Protocol Version 6

The number and range of networked devices that use internet addresses are continually increasing: this includes technologies in cooperative systems. As demand for addresses continues to grow, it is time to start using the next generation Internet Protocol: IPv6 (Internet Protocol version 6 - www.ipv6.org).

The internet connection in the CVIS platform uses IPv6. Although it is foreseen ultimately that there will be an overall upgrade to IPv6, most European countries are still dominated by IPv4 and would need to upgrade their Protocol in any communication hardware that is used. There are several reasons why CVIS uses IPv6 over the currently dominant IPv4 (and since IPv4 is still dominant, CVIS can still 'tunnel' into systems which use IPv4).

IPv6 allows for enhanced security, particularly for wireless internet, as well as increased ease of use for plug-and-play applications and the possibility of having geographic-based services with devices using IPv6 (although, if privacy is an issue, this can be switched off). CVIS is compatible with IPv6, even though in most places this Internet Protocol is not yet in use. It is foreseen that IPv6 will ultimately replace IPv4, and it is seen as a key driver for many new wireless applications and services which might be too complicated and/or costly in an IPv4 environment[4], since it allows for a growing number of internet addresses.

Referring again to the figure showing the components of the CVIS system (page 43), the CVIS Host (in vehicle or RSU) and the CVIS Routers will run IPv6. CVIS is not going to deploy a separate IPv6 network: it will be part of the global internet and will make use of any available access network to connect vehicles to the Internet (3G, WLAN, infrared, etc) –see figure demonstrating the CALM overview.

Source: Q-Free

Architecture

A system architecture provides a framework – based on user requirements – for planning, defining and deploying cooperative systems[5]. The cooperative systems architecture provides a basis for the deployment of the safe, secure, fault tolerant and interoperable cooperative systems. The CVIS project is cooperating with other projects and stakeholders to develop an architecture for cooperative systems technology. It is in the context of projects such as CVIS that the European communications architecture for cooperative systems has been made possible.

The architecture:

- Delivers a means of ensuring interoperability between components developed by different manufacturers as well as ICT vendors.
- Ensures the safe use of cooperative systems, so that the systems do not lead to dangerous circumstances and accidents.
- Addresses the issue of security: both to protect personal data, and to protect against malicious attacks against the systems.
- Addresses policy issues and Directives such as vehicle approval regulations, security, privacy, and legal liabilities.
- Is designed to be future-proof: this means that the architecture is fixed even if some specific technology standards will change or specific technologies will be replaced in the future by better ones.

The architecture connects in-vehicle systems, roadside infrastructure and back-end infrastructure that is necessary for cooperative transport management. The CVIS architecture and specification is implementation-independent, i.e. it allows different implementations for various client and back-end server technologies: however, for the reference execution environment, CVIS is bound to specific technologies in order to create a fully functional system. These specific technologies to which CVIS is bound are Java / OSGi running on top of Unix operating system.

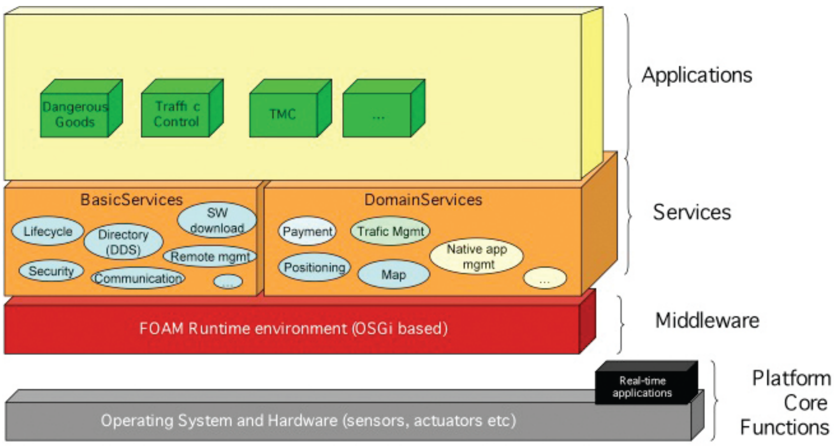
The CVIS architecture is a layered architecture as shown in the figure below. A main principle of a layered architecture is that a particular layer communicates only with those layers which are directly above or below it.

The top layer is denoted the applications layer which contains the set of applications run on an OSGi based execution infrastructure. An application provides end user services, where examples of 'end users' are traffic managers or drivers. The middleware layer consists of two sub-layers: the facilities layer (to support the operation of applications) and the OSGi based execution infrastructure layer (which provides an environment for Java and OSGi to run functions). The third layer is the platform core functions layer, the main part of which is the communication infrastructure layer which includes the communication infrastructure: operating system, routers, gateways and hardware (sensors, actuators, antennae, etc).

Requirements are built in within this layered architecture. For example – based on measures from existing projects – security measures are built in which ensure secured communications and encryption of data. System management, policy issues and organisational elements are also considered.

For more detailed information on the CVIS architecture, please refer to D.CVIS.3.3 Architecture and System Specifications available on the CVIS website.

For information on the European Communications Architecture for Cooperative Systems, please refer to: http://ec.europa.eu/information_society/activities/esafety/doc/esafety_library/eu_co_op_systems_arch_sum_doc_04_2009_fin.pdf



CVIS Layered Architecture. Source: CVIS

An open & interoperable system

Openness is about being able to add new services and new or enhanced components within the cooperative systems framework without adverse side effects. It is about getting services and applications to understand one another (especially when they address common aspects), and allowing different implementations (ie different hardware patterns, operating systems etc.) without interoperability problems.

The idea is to design systems for an open, heterogeneous and interoperable world, in which systems will interact that:

- are designed and implemented by different vendors;
- range from brand new to 10 years old;
- can be cheap and basic, or laden with add-on features;
- have to deal with different local regulations.

CVIS is an open platform: board drawings are readily available, and the basic core software and middleware (see section on architecture above) are open and run on Linux. However, application software and other software components are not open, so manufacturers can still protect their intellectual property.

The openness and interoperability are built into the CVIS core framework, and into the CVIS applications. However it is a careful balance to build in openness, and not leave the system open to abuse: to programs which are not properly designed (if anyone can create applications, they could be poorly made, and have bugs in them), or to malicious attacks.

A key area to ensure interoperability is to have proper standards: these standards are not developed within a European project such as CVIS, although such a project can help push the momentum forward for standards to be developed.

The European Commission Decision 676/2002/EC allocated a radio spectrum dedicated to ITS in the 5.8 GHz frequency band. Along with CALM (see section on CALM) – an initiative hosted by the International Standards Organisation – this goes some way for the cooperative ITS communication standardisation. Additionally, there are standards on other aspects of cooperative systems – such as special standards for communications regarding safety applications (eg for warning systems) – but since the technology is new, so are the standards. A comprehensive review of where standards are required, as well as the standards actually being put into place is still not completely comprehensive.

For more information related to the issues of openness and interoperability addressed in the CVIS project, please refer to the CVIS deliverables: DEPN Openness and interoperability, and high level architecture deliverable available on the CVIS website: http://www.cvisproject.org/en/public_documents/deliverables/

Interoperability: a vehicle unit from Spain should be able to communicate with this RSU in Germany. Source: PTV

How to finance cooperative systems?

Costs

The costs for CVIS functions are made up of the costs of equipping the infrastructure and running of CVIS services and can be split into the following elements: the onboard unit costs, RSU costs, the control centre costs (maintenance costs are also split along these three lines), the communication costs and the costs for providing services.

As was seen in the section above, the major costs for the local authority are associated with the RSUs and the control centre: setting them up and maintaining them. In the figure of costs related to the CVIS system (next page), you can see a description of the main costs associated with cooperative systems technology. These are the areas that need to be considered when installing cooperative systems technology.

The purchase and installation costs consist of:

- physical infrastructure costs determined on the basis of the generic equipment that is required (this is dependent on the application under question);
- installation costs for both the installation of roadside and in-station equipment.

Operating costs consist of:

- staffing, taking into account how many operators and managers may be required (this is dependent on the CVIS application under question);
- accommodation, taking account of office space for the operators, managers and the in-station equipment;
- maintenance: general day-to-day maintenance costs and equipment renewal costs (which are generally different for roadside and in-station environments);
- communication costs;
- other operational factors, such as the cost of using the services of various public or other communications service providers.

Set-up costs from scratch include setting up roadside units, where the number of CVIS RSUs required – as mentioned earlier – is dependent on the CVIS application under question, the legacy systems in place and on the communication media used in the RSUs. Cooperative vehicles require a positioning, communication and processing system (personal navigation device plus two-way communication capability via wireless communications); roadside units require communication capability.

A future RSU structure could be an extension of an existing traffic controller at incremental cost, and maintenance efforts should not significantly increase. However, if RSUs are installed at locations where there is currently no traffic controller, the cost would be as high as installing a new controller.

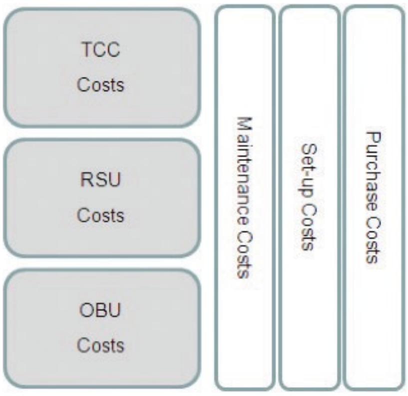
The CVIS project is a research project, and it is not foreseen that the hardware that is developed in the project will be ready straight away for commercial roll-out. This has repercussions in terms of cost: current costs cannot be taken into account for estimating the actual set-up and maintenance costs. The hardware is currently expensive, but as production scale increases (in a few years) prices will drop. Cooperative technologies follow the typical price trend of information technologies, where normally a 25-30% drop in price can be seen for each doubling of volume.

To estimate maintenance costs and payback costs: these will be comparable to the maintenance costs of traffic light controllers.

If the local authority decides to equip some vehicles with cooperative technology, then the cost on the vehicle side needs to be considered as well, since the vehicle has to be equipped with cooperative functionality. If this is carried back-pack on an existing OBU (eg for tolling or navigation), the cost of cooperative functionality might be incremental. If however dedicated cooperative OBUs need to be installed, the cost would be significant.

There was some mention above of how CVIS technology optimises the communication based on signal strength, connectivity and price. This implies that there is a cost for licensing for the use of a frequency bandwidth for wireless communications: however, this cost is low, and could conceivably be applied to a third party for use of the service (ie the end user: private driver or fleet manager).

Additionally – depending on the application – the local authority will pay a fee to the service provider for the service that is provided to them. This will depend on the application, and on the service provider (see the conceptual business models below).



Costs related to CVIS system (TCC = traffic control centre). Source: CVIS

CVIS RSU next to a traffic light. The major costs for the local authority are associated with the RSUs and the control centre. Source: Peek Traffic

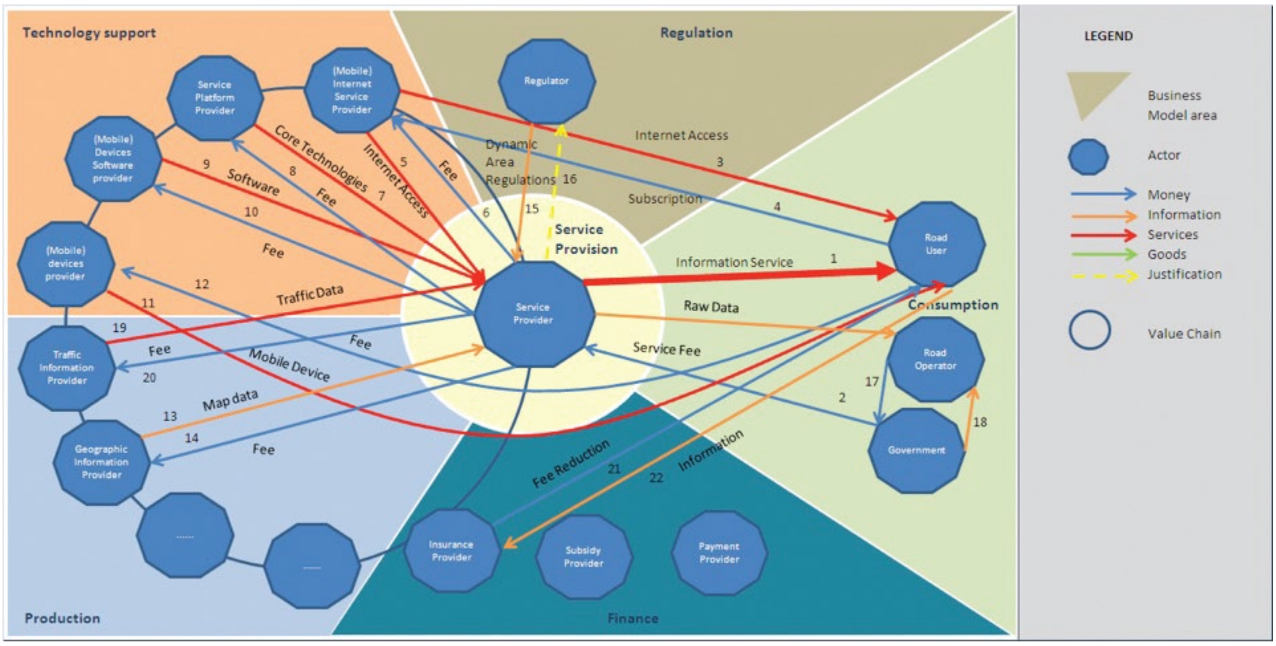
Business models

There are many actors involved in the deployment of cooperative systems. For a business model to be created, each stakeholder must see a business opportunity in the deployment of cooperative systems: this makes the business models complicated, to say the least, as different stakeholders have different perspectives.

To take into account the different stakeholders' perspectives, and to ensure a business model for all, applications could be introduced in bundles, and the bundle services should be developed according to different standpoints:

- The (local) government perspective to support transport policy goals;
- The road users' perspectives to increase comfort, risk reduction, efficiency and safety;
- The freight operators' perspective to build an effective logistics systems.

In the figure, you will see a conceptual business model for the Dangerous Goods Application (see page 35). This conceptual business model provides notions of how the different actors interact with each other in the system: who provides services for whom, and who pays for services from whom, and can just to be seen as an example at this stage.



The Service "Dangerous Goods / Route guidance" modelled with Conceptual Business Modeller. Source: CVIS

The conceptual business model for the Dangerous Goods Application is divided into different areas:

1. Consumption

This area represents those actors who are perceived as consumers: the truck drivers are service consumers, and the road operators and local government authorities are information consumers. They pay the service provider for services delivered to them.

2. Service Provision

This area represents those actors who provide services to the consumers. For the Dangerous Goods Application, apart from this service itself, this includes the geographic information provider, and the map and weather data providers.

3. Production

This area represents those actors who produce the services and deliver functionality to the service provider or directly to the consumers. For the Dangerous Goods Application, this includes map data and traffic data provided to the service provider.

4. Technology Support

This area represents those actors who support the producers of the services or the service providers with the necessary technologies, providing telecommunication, software and hardware for the Dangerous Goods Application.

5. Finance

This area represents those actors who support financial transactions within the business model. For the Dangerous Goods Application, this is represented by the insurance provider, who is involved because the application will provide safer conditions for the shipment of dangerous goods, with an associated reduction in insurance premium for the freight company which uses the application.

6. Regulation

This area represents those actors who monitor compliancy with legislation related to the services. For the Dangerous Goods Application, it is the government which makes sure that all activities follow the law.

Actors & Value Streams

Different actors are separated within the different areas as defined above. Value streams consist of money, information, services and goods. These are what the actors exchange with one another in the business model. An example can be seen in the figure. For the Dangerous Goods Application, information is provided by the road operator to handle routing, and the information is tracked and handed back to local authorities. Road operators and local authorities will pay a fee to the service provider, since they receive a service (reduced risk of accident and information on dangerous goods in the area). System users (trucks), pay a fee for mobile connectivity, but will have a reduced insurance premium as a motivating factor for paying this fee.

Conceptual business models are provided for all of the CVIS applications in the CVIS deliverable D.DEPN 5.1 Costs Benefits and Business Models, available on the CVIS website.

The fact that cooperative systems business models involve many actors can make deployment very difficult. In order to ease deployment, it is best – in the beginning – to try to find applications (or bundles of applications) which have simple business models. An example from the CVIS project is the Priority Application: for this application, no mapping information is required, no insurance provider is involved, and no road operators are required. The application involves the road users, local authority, regulator, technology support, service provider and traffic information provider. Although there are still many stakeholders involved, there are not as many involved as there are for the Dangerous Goods Application.

Interview

Wil Botman, Director General European Bureau, Fédération Internationale de L'Automobile (FIA)

How do cooperative systems tackle urban transport challenges?

Cooperative systems provide an extremely interesting development in and outside urban environments. The ways in which cooperative systems can tackle urban transport challenges are mainly in road safety: at junctions (see examples from Safespot project), in terms of reducing collisions, in protecting vulnerable road users (this is still a big problem which needs to be tackled). People in the ITS world think that there is a big potential in improving road safety through cooperative systems using radars and screen displays.

How do cooperative systems fit into an overall traffic management / ITS strategy?

There's an increasing role for cooperative systems in overall traffic management.

Cooperative systems are a very important part of ITS strategy. Examples of applications that will be seen are electronic stability control, lane keeping and adaptive cruise control. Cooperative systems do not provide such a big potential for traffic management, although they do provide potential in terms of floating vehicle data, and a big potential for safety. Information-type cooperative systems are about convenience, although they can also have secondary benefits, for example in terms of bringing energy consumption down.

The next big step for ITS will be cooperative, and we need new technology for this.

What are the major challenges to deployment?

It will be extremely difficult to deploy cooperative systems. Investment needs to be made by many stakeholders who all need to be sure that the others will invest. Some kind of commitment is required, but it is not sure how this will be accomplished (take eCall for example, which moves very slowly for this reason).

Additionally, the vehicle manufacturers need to go in the same direction in terms of development; business models are extremely important; as is timing and commitment of all stakeholders.

What is your vision for cooperative systems?

Cooperative systems are the future. They provide a big potential gain in the area of safety. However, they require massive involvement from both public authorities and industry.

> "The next big step for ITS will be cooperative."

Part IV Non-technological deployment issues

To deploy cooperative systems, non-technical deployment issues need to be addressed. This chapter looks at some important issues that need to be considered if deployment of cooperative systems is to be achieved.

In order to have cooperative systems ready for deployment, the technology needs to work, but there are also several non-technical issues that need to be considered. In fact, it is crucial to discuss the market feasibility as well as the technical feasibility of cooperative systems, otherwise there is no chance that the system will be deployed.

This section will look at some of these issues: topics which have been considered within the CVIS project, and which have been highlighted as possible barriers to deployment: user acceptance, data privacy, standardisation, legal and liability issues and stakeholder cooperation.

These non-technical issues should be taken into consideration when building and deploying cooperative systems technologies. Ensuring that cooperative systems technology is deployed means ensuring that the non-technical issues which could hinder successful deployment have been addressed and that there is a real understanding as to how to move from the current situation where vehicles are not equipped to widespread take-up of the system.

User acceptance

One possible major barrier to deployment of cooperative systems is that of user acceptance. The 'users' here refer to the vehicle drivers, but also to the road authorities. User acceptance can be split into three parts:

1. The utility and usefulness of the system from the driver's point of view;
2. The utility and usefulness of the system from the road authority's point of view;
3. The usability of the system.

1. The utility of the system to drivers depends on the applications under question, and on the type of driver: private driver (commuter, leisure driver, etc); freight driver; public transport driver, etc. To make the applications useful for drivers, and to test the utility of the systems among this group requires questionnaires, studies and field tests. This has been started within the CVIS project in which the user acceptance of the CVIS system by private drivers was investigated through an internet-based questionnaire distributed to 13 automobile clubs in 12 countries.

Respondents to the questionnaire (approximately 8,000 people) were presented with different CVIS applications and asked to rate the applications' usefulness. The results from the questionnaire showed that more than 50% of those who responded thought that the CVIS applications are quite useful or very useful.

The motorists were also asked about their willingness to pay for services, and although the usefulness of the CVIS applications is higher than the willingness to pay for them, around 40% state that they would accept to pay for them. This means that there can be a positive business case for most of the applications.

Data privacy is an area of concern: 77% of respondents mind the systems invading their privacy (the other 23% do not mind the invasion of privacy, but only because they find the systems useful). However, when it is specified that only car data is involved (ie no personal data is transmitted from vehicles), 60% of respondents would agree to being geographically located.

For more information on these questionnaires, visit: www.cvisproject.org/en/public_documents/end_user_survey/

2. Road authorities must also find benefits arising from cooperative systems in order for deployment to go ahead. There must be a clear use for the cooperative systems technology to foster user acceptance among this key stakeholder group. Again, the utility of the applications to this group depends on the applications under question, and on the road authority under question (urban, regional, or national level).

Field tests, studies and questionnaires will help to understand which applications this group finds useful. The CVIS project has made a first step in addressing user acceptance amongst this group, through a survey completed by representatives of European road operators.

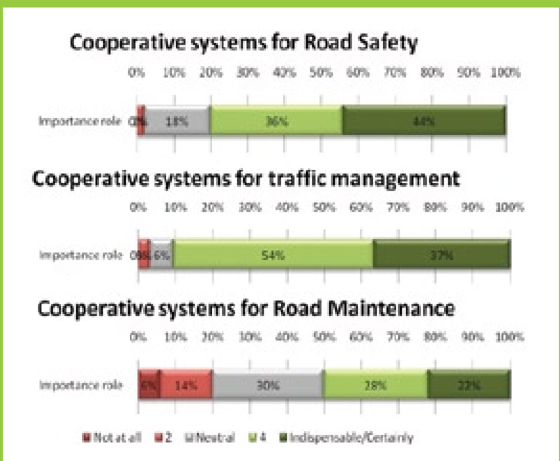
The road operator questionnaire was completed by 42 respondents, the majority of whom categorised themselves as having an above average familiarity of cooperative systems. Although this survey in terms of methodological issues is not representative for all road operators in Europe, it gives a first idea of this stakeholder group's view on cooperative systems. More information on the respondents of this trial can be found in Appendix 1.

Of four application areas, the respondents highlighted road safety as the most important area, followed by traffic management and congestion management. Road Maintenance was considered the least important.

- 44% of respondents thought that cooperative systems play an indispensable role in road safety;
- 37% of respondents thought that cooperative systems play an indispensable role in traffic management;
- 22% of respondents thought that cooperative systems play an indispensable role in road maintenance.

The statistics from the image below are based on the following question (replace 'X' with 'road safety' / 'traffic management' / 'road maintenance'):
"Do you think cooperative systems can have an important role in X ?

No, not important at all ○ ○ ○ ○ ○ Yes, they are indispensable"



3. As well as questions of utility and usefulness of the system, it is also important to incorporate ease of use into the design of cooperative systems; this is to ensure both the safety and satisfaction of the users of the systems. This is relevant primarily with respect to the HMI device.

Firstly it is the usability of the HMI device itself that is of importance, and then it is the usability of each application that has to be considered. Examples of issues that should be addressed include: whether the driver should touch the screen or receive automatic messages; or whether the driver should only touch the screen in cases when they are not in a complex driving situation (ie approaching a junction) etc.

These types of issues need to be addressed by using simulator studies and field tests. The CVIS project has done a small-scale simulator study to look at some of these issues. This is a starting point, but more needs to be done.

Security and data privacy

Security is critical to cooperative systems, to ensure that the systems are not subject to vicious attacks, false messages, jamming, or corruption of data. Additionally, cooperative systems foresee the creation, storage and exchange of personal data over wireless communication links. The increased data benefits of cooperative systems in terms of floating vehicle data provide one of the major advantages of the technology, but a huge amount of location data (which could be considered as personal data) is generated, and this could be problematic in terms of privacy issues.

Privacy is a major issue for potential private car users of cooperative systems – as touched on in the previous section on user acceptance – and needs to be dealt with adequately by those developing the technology so that the concerns are built into the system from the outset, and so that the technology can be accepted by the users.

Within the CVIS platform, the concerns of security and data privacy have been built into the communications architecture and a number of key principles have been adopted. For example, the communication architecture requires that the identity of vehicles will be concealed and that information will be digitally encrypted. CVIS collaborates with other European projects which tackle security and data privacy threats together in a coordinated way (eg privacy is addressed in the PRECIOSA project (www.preciosa-project.org); and security issues are addressed in the SeVeCom project (www.sevecom.org)).

Security in the European Communications Architecture

"The security component of the Communications Architecture is designed to be future proof, that is to say, the architecture is fixed, even though some technology standards will change, or specific technologies may be replaced in the future with better ones. Secondly, as vehicles will be periodically broadcasting their position and sending other information, the identity of vehicles will be concealed to protect privacy against both malicious and casual observation. This means that permanent identifiers and addresses will never be communicated over the air. Thirdly, to ensure trust in messages, these have to be digitally signed. Signing of messages is designed to ensure that tracking and tracing will not be possible, and is based on the use of assigned temporary pseudonyms, which are periodically revised, thus making it difficult for outsiders to fabricate digital signatures." [6]

Source: The European Communications Architecture for Co-operative Systems. Summary Document, April 2009.

Standardisation

Standards are required in order to ensure that when components of cooperative systems are manufactured by different companies and in different countries, they will still work together. One of the key components of the cooperative system is interoperability, and making sure that the standards are coherent is clearly an important issue to solve.

When standards are not created centrally, different companies will create different ways to solve the same problem: this proliferation of incompatible ITS standards is very inefficient, leading to unstable conditions for deployment of ITS cooperative systems. A fragmented approach leads to increased cost, deployment delays and increases the risk of compromising safety and efficiency.

European research and development projects (such as CVIS) on ITS cooperative systems have developed the technical and scientific background for European standardisation within the 5th, 6th and 7th Framework Programmes of the European Commission. These research results are now being transferred to the ETSI (European Telecommunications Standards Institute) and CEN (European Committee for Standardisation) with the aim of promoting Community-wide technical standards and specifications. It is clear that developing clear European-wide standards is key to ensuring the deployment of cooperative systems. Some standards already exist (such as CALM, DSRC, and standards for cooperative warning and control systems), but others need to be created in order to enable smooth deployment of cooperative systems (see also section on openness and interoperability in part III.

Standardisation is a priority area for the European Commission highlighted in the ITS Action Plan as a way to achieve European and global ITS cooperation and coordination. Standardisation for cooperative ITS systems has already been initiated both by ETSI and ISO (International Standards Organisation) as well as within other international standards organisations.

A draft standardisation mandate on cooperative systems has already been scripted in order to prepare a coherent set of standards, specifications and guidelines to support European Community-wide implementation and deployment of cooperative ITS systems. The mandate supports the development of technical standards and specifications for intelligent transport systems within the European standards organisations in order to ensure the deployment and interoperability of cooperative systems, in particular those operating in the 5 GHz frequency band within the European Community.

For more information, please see:
http://ec.europa.eu/information_society/activities/esafety/doc/2009/mandate_en.pdf

http://ec.europa.eu/transport/its/road/action_plan_en.htm

Legal issues and liability

Another obvious area to consider is that of legal and liability issues: if something does go wrong – and at worst there is an accident – is anyone liable? Liability issues need to be considered before the systems are deployed to ensure that a solid liability structure is in place and that all stakeholders are assured of what will happen if something does go wrong.

It is a requirement from the 1968 Vienna Convention (United Nations' Economic Commission for Europe Convention on Road Traffic) that drivers must control their vehicles at all times. Thus, cooperative systems applications should largely be capable of being assimilated within the framework of the current primary legislation and criminal and civil liability since the focus remains on the driver retaining ultimate control, albeit increasingly assisted.

Indeed it makes sense for new drivers to be taught this when they are obtaining their driving licence: to learn that they are in full charge of their vehicle and that any onboard units are there only to aid them.

Careful consideration should be given to the type of aid that is given to drivers via their onboard unit. Obviously, messages such as "safe to cross junction" will engender liability implications if an accident occurred. Messages such as "watch out – pedestrian ahead" will not, even if the message is not displayed due to a system failure. The driver alone remains responsible.

If the service provider gives wrong information to the local authority, then the local authority may want to take action against the service provider: methods for monitoring the transfer of data, and thus proving any inconsistencies would be required.

The main role of the local authority in cooperative systems applications is in managing the efficient and safe circulation of traffic over that part of the network for which it has responsibility. This management is primarily in the form of delivering information (usually in the form of messages) to its road users.

If an accident occurs because the authority introduces a warning system which aids drivers, it is possible that the authority might be held responsible for the consequences of a failure occurring in the delivery of that service – if the reason for the failure was some fault or neglect on its part.

To think a little bit more about possible faults or neglect, some typical scenarios that can be envisaged:

a. The authority would be liable for any inaccuracy in the messages it sends, but if that inaccuracy stemmed from a deficiency in the information acquired by the authority from a third-party service provider then the authority may have rights of recourse against the service provider, depending on the terms on which the service was provided.

b. The authority would be liable for any failure of the RSU equipment to function properly (since this equipment is likely to be under its control and responsibility), unless this was caused by some 'force majeure' event, such as extreme weather conditions or other natural or man-made catastrophe. On the other hand, the authority would not be responsible if the fault lay in the OBU, since that would not be under its control. However, it would be difficult to prove that the fault lay with the RSU.

c. The authority would not be liable for a failure in communication between it and its road-users, where the communication service was provided by an independent third party service provider.

d. The authority may be liable for failure to provide a warning when one should have been provided. It may depend on whether a court will be prepared to find that the authority had created a situation in which its road-users had the right to expect warnings to be provided in circumstance where they were needed.

In any consideration of the liability of the local authority in the above scenarios, the action taken by the authority to alert the road users to the malfunctioning of or breakdown in the service would be a relevant factor. As with cooperative systems in general, the user builds up an expectancy that the system will be working and working correctly. The user, therefore, needs to be alerted immediately when this is not the case, and also if the communication technology is not working. Once the alert is received, the user knows that 'she (he) is on her (his) own'.

Given all of this, legal systems rely on a system of proof, and proving malfunctions in the cooperative system technology is likely to be difficult to prove.

For more information on liability issues and risks, please see D.DEPN.6.1 at http://www.cvisproject.org/en/public_documents/

Multi-stakeholder cooperation

Getting OEMs, suppliers, public authorities, telecoms industries and others to work together is not an easy feat, but in deploying cooperative systems, it must be managed. Without the cooperation of all partners, cooperative systems cannot be deployed.

Projects such as CVIS are so important in the development of this technology precisely because they bring so many different stakeholders together. A lack of proper cooperation between stakeholders could be a major barrier to the deployment of the technology.

One way to help ensure that all stakeholders become involved in deployment, and cooperate with each other, is to ensure that each stakeholder has a good business model for deploying cooperative systems: this involves calculating costs, and benefits for each stakeholder. This is discussed in Part III (See page 53), and has been considered within the CVIS project.

Interview

Steve Kearns, Stakeholder Manager, Transport for London (TfL)

How do cooperative systems tackle urban transport challenges?

Cooperative systems can help to tackle congestion problems, for example in terms of enhanced real-time data capabilities. The data which we use at the moment tends to be historical rather than real-time, and with cooperative systems – and the possibilities of floating vehicle data – it will be possible to communicate directly with drivers about what's happening in the network. However, with all of this extra real-time data, there may be difficulties with data processing. We need to make sure we devise systems that overcome such potential problems.

The Mayor of London talks about "smoothing traffic flow", and within the context of freight (as the CVIS trial in London was concerned with a freight application (see page 30)), the Mayor identified that freight double parking, not accessing parking bays and circling around the block were major causes of congestion. Cooperative systems have a capacity to help solve these problems. Generally, there is a central role for cooperative systems to tackle urban congestion in the future.

How do cooperative systems fit into an overall traffic management / ITS strategy?

There's an increasing role for cooperative systems in overall traffic management.

Cooperative systems can help to identify when there's a problem on London's roads: two examples of when this could be useful is in supplementing cameras in identifying when there's a problem (there are many cameras on the roads in London, and sometimes too many screens for the controllers in the traffic management centre to follow, so cooperative systems could supplement the cameras in identifying problems in the network), and also in adapting traffic signals (which are currently about 50% fully automatic) when there's a problem.

Cooperative systems are a central part of ITS strategy. TfL are trying to highlight how to use ITS and incorporate cooperative systems into the Mayor's strategy of "smoothing traffic flow".

What are the major challenges to deployment?

Following experience in the CVIS trial, major challenges are: effective communication between stakeholders, scalability (the systems designed for tests must be able to work on a large scale), enforcement (enforcement worked for the trial because it was on a small scale), privacy, and technophobia (some people have no experience of such technology, and this could be a problem!).

What is your vision for cooperative systems?

In the future, the equipment should be hardwired inside vehicles to help vehicles to drive around London and do business around London. Cooperative systems need to be thought of within an overall transport vision for London: not just for vehicles, but for other users as well. In London, there are big pedestrian flows that need to be managed, and we need optimum balance of traffic, pedestrians and cooperative systems. Other ITS features such as mobile phone data and the image recognition detection system that Transport for London are developing will also be important in this respect.

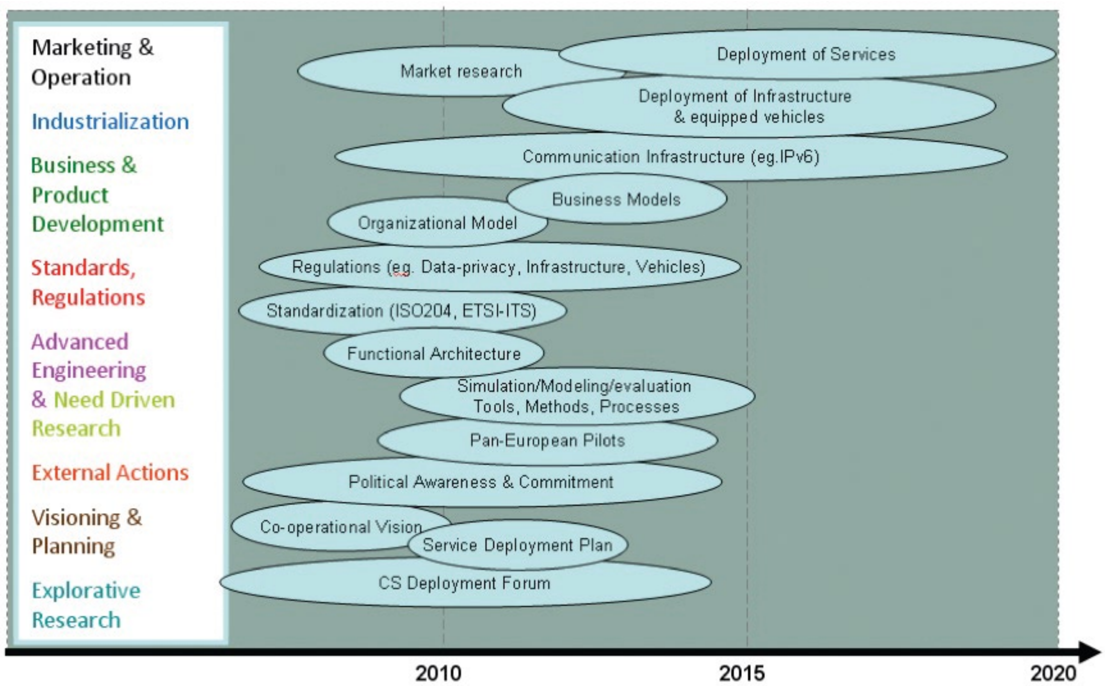
> "There is a central role for cooperative systems to tackle urban congestion in the future."

Deployment roadmap

Deploying cooperative systems is not just about getting a new technology to work. As seen in this chapter, other influences are at play in deploying cooperative systems. In order to address all elements relative to deployment, a deployment plan or roadmap must take into consideration costs, benefits, risks, liabilities and control over policy decisions, as well as influences such as public demand for safe and efficient traffic of people and goods; commercial transport needs; the individual need for personal mobility; quality, maintenance, etc.

To see how all of these elements fit together, a roadmap has been considered by the CVIS project: in the figure below, the aggregated deployment roadmap is shown below. This roadmap takes into account both technical and non-technical elements needed in order for deployment to take place.

The aggregated deployment roadmap is loosely applied to a timeframe from the present day until the year 2020: this is to give an idea of what steps need to be taken, and in what order, but introducing any new technology is unpredictable, so this roadmap is provided only to give an idea of the steps that need to be taken, and should not be considered as an accurate description of when exactly things will take place.



Aggregated deployment roadmap. Source: CVIS

Deploying CVIS vehicles requires more than just the technology.
Source: Siemens

Part V Moving forward: evaluation & deployment scenarios

This chapter looks at the future steps for cooperative systems: in terms of evaluation and field operational tests (FOTs), but also in terms of how cooperative systems fit within European policy framework, and how deployment can be driven by different scenarios.

It is one thing to say that cooperative systems can bring many benefits, but can they really deliver as promised? Evaluating the benefits of cooperative systems is important, not just in order to check that the benefits can be achieved, but also in order to secure investment for the systems, and provide solid evidence for the deployment of the systems. Evaluation is not just in the form of desk studies, but also in the form of testing of the systems in the field in order to show the capabilities. Field Operational Tests (FOTs) are large-scale testing programmes which aim to provide a comprehensive assessment of the efficiency, quality, robustness and user acceptance of ICT solutions.

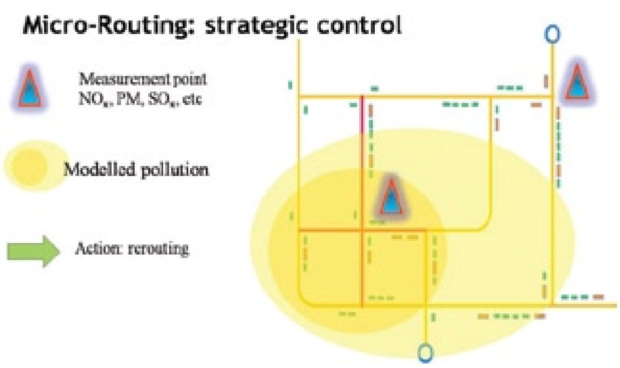
FOTs are used to test mature technology of which the effectiveness has been proven in simulation (modelling) studies. FOTs are usually the last step before broad deployment of ICT solutions.

This chapter looks at the future steps for cooperative systems: in terms of evaluation, but also in terms of how cooperative systems fit within a policy framework, and how deployment can be driven by different scenarios.

Testing the CVIS equipment. Source: Volvo Technology Corporation

Evaluation studies

There are few evaluation studies related specifically to cooperative system technologies so far. However, the methods used to evaluate cooperative systems will follow those used in evaluating general ITS systems. The type of studies that are performed are based on:



Microsimulation modelling of Micro-Routing Application, showing pollution points in small network. Source: Jaap Vreeswijk, Peek Traffic

- Simulation studies / studies based on models: for example, some small scale examples exist for applications within the CVIS project;
- Studies from driving simulators (for example to test HMI interaction);
- Studies from questionnaires: for example, those seen to test user-acceptance (though for small samples) within the CVIS project;
- Field operational tests.

For more information on evaluation of ITS systems in general, useful websites include:

- The ITS benefits database run by the USA Department of Transport (US DOT): www.itsbenefits.its.dot.gov/its/benecost.nsf/BenefitsHome
- The eSafety effects database which contains a database of studies of the effects of different eSafety systems or intelligent vehicle safety systems www.esafety-effects-database.org
- Currently two EC-funded projects undertake efforts in creating tools to assist local authorities in making investment decisions on ITS: CONDUITS (www.conduits.eu) and 2DECIDE (www.2decide.eu)

It is relevant to evaluate different aspects of cooperative systems: safety, environmental, traffic and socio-economic effects. Safety was recognised from early on as being an area that could benefit greatly from cooperative systems, and the majority of existing evaluation studies relevant specifically to cooperative systems refer explicitly to safety applications. Examples of projects that look at this area are the eImpact project (www.eimpact.info) and the eSafety effects database (www.esafety-effects-database.org) which – although they look at intelligent safety systems overall – have some examples of particular focus on cooperative systems. These projects focus on safety applications, but consider other aspects in the evaluation of the systems: for example the eImpact project considers traffic effects and evaluates the cost benefit analysis of the applications under question.

Existing modelling results are generally from microsimulation. Models will always have to make some assumptions, and in order to model the possible effects of cooperative systems, the penetration rates of equipped vehicles must be estimated. Studies differ in their approach to this, with some deciding on a figure or range (based on other studies, expert guidance) on which to base their study (for example the CODIA report[7]), and some looking at different penetration rates, and different possible impacts due to the different penetration rates (for example ISA report[8]). Because of the importance of penetration rates, the uncertainty of future rates, and the impact that this has on evaluation, it is important that different values are taken into consideration, or at least good reason is given for why a given rate is used.

Other assumptions used in microsimulation models, as well as in cost benefit analysis are: the costs of the equipment and the effects of the technology on the driver (this is along with standard assumptions used in transport modelling: the costs of injury / death / emissions etc; the classes of users modelled and their value(s) of time; the fact that road users are utility maximisers; etc).

The evaluation of cooperative systems will be more robust when the penetration rates, system costs and effects on the users are better known.

Apart from the general lack of evaluation specifically relevant to cooperative systems technology, what is lacking in existing studies is that only standalone cooperative systems technologies have been considered, and as has been shown in this document, the benefits of cooperative systems will become greater when take-up is widespread and several applications are run in parallel on the cooperative systems platform.

More ambitious evaluation of cooperative system technology awaits future research such as the results of the studies from projects such as iTetris (www.ict-itetris.eu, a project that aims to develop advanced large-scale computing analysis to analyse wireless technologies), and from field operational tests.

iTetris project

iTETRIS is an EC-funded project which aims to create a global, sustainable and open vehicular communication and traffic simulation platform in order to facilitate a large scale, accurate and multi-dimensional evaluation of cooperative ICT solutions for mobility management.

iTETRIS is devoted to the development of advanced tools coupling traffic and wireless communication simulators. This will enable large scale computing analysis with the aim to provide a valid supporting tool for city road authorities to get a first insight of the potential of cooperative systems. iTETRIS will provide the possibility of running simulations involving metropolitan areas, over long time scales and a large number of vehicles to evaluate potential cooperative systems applications (or bundles of applications). If it is assumed that a given city already contains cooperative ITS system technologies, the tool developed by iTETRIS can be used for optimisation policies.

www.ict-itetris.eu

Field operational tests

A number of field operational tests (FOTs) have been conducted or are currently running, which aim at testing the efficiency, quality, robustness and user acceptance of applications (or use cases) based on cooperative systems technology on a large scale in a real life environment. These FOTs provide further information about the possible use and impact of cooperative systems based services. An overview of relevant FOTs is provided by FOT-Net - Networking for Field Operational Tests (www.fot-net.eu/en/fot_timeline/).

This picture shows how an eye/face tracker is used in a FOT (or other test) to collect data on driver behaviour. Source: euroFOT

Some examples of such FOTs are given here:

FREILOT

The FREILOT project focuses on reducing energy consumption of goods delivery vehicles in urban areas. The FREILOT service aims to increase energy efficiency drastically in road goods transport in urban areas through a holistic treatment of traffic management, fleet management, the delivery vehicle and the driver, and to demonstrate in four linked pilot projects that up to 25% reduction of fuel consumption in urban areas is feasible. The project is testing four services based on the CVIS technology:

- Energy efficiency optimised intersection control - traffic management;
- Acceleration limiter and adaptive speed limiter – vehicle;
- Enhanced "green driving" support – driver;
- Real-time loading/delivery space booking – fleet management.

For further information see www.freilot.eu.

sim^{TD} – Sichere Intelligente Mobilität Testfeld Deutschland

The sim^{TD} project is funded and supported by the German Federal Ministries of Economics and Technology, Research and Education, and Transport, Building, and Urban Affairs as well as the State of Hesse. The automotive, supplier, and telecommunications industries investigate jointly with the public sector and scientific institutions the possibility of improving traffic safety and mobility with car-to-infrastructure and car-to-car communication. The sim^{TD} test sites include motorways, rural roads and inner-city roads. The project started in September 2008 and will run for four years. Among the applications that will be tested:

- Data collection on the infrastructure side
- Data collection by the vehicle
- Identification of traffic situation
- Advanced route guidance and navigation
- Optimised urban network usage based on traffic light control
- Traffic light phase assistant /Traffic light violation warning
- Intersection and cross traffic assistance

For more information see www.simtd.de

SPITS - Strategic Platform for Intelligent Traffic Systems

The Dutch SPITS project mainly aims at minimising congestion and optimising fuel consumption. SPITS is the Strategic Platform for Intelligent Traffic Systems: SPITS will create an open, scalable, real-time, distributed, sustainable, secure and affordable platform for cooperative ITS applications, evolving from existing infotainment systems. Starting from knowledge on existing onboard units, combined with knowledge developed in European and other programs, SPITS aims to:

- Build the next generation onboard units that are open and easily configurable for OEM specific requirements. They will also be (hardware) upgradeable, which will allow innovation during the lifetime of the system and lead to faster adoption of new technologies;
- Adapt existing roadside units to support cooperative technology and to supply local information about all traffic;
- Build the next generation of back offices, that can offer services to either onboard units or Roadside Units, and that can realise remote service life cycle management.

SPITS will test a range of cooperative applications in several Dutch cities and interurban roads, for example Flexible Bus Lane, ecodriving support, routing advice, and road pricing.

For further information see www.fot-net.eu/download/stakeholder_meetings/3rdStakeholdersworkshop/09__spits.pdf

CICAS - Cooperative intersection collision avoidance systems

The US programme CICAS supports field operational tests of applications addressing the following crash types: traffic signal violation, stop sign violation, intersection manoeuvres at stop signs, and unprotected left turns at traffic signals. (More information: www.its.dot.gov/cicas/index.htm)

The European ITS action plan

The European ITS Action Plan from December 2008[9] explicitly mentions cooperative systems in several places, and within its general framework, the benefits offered by cooperative systems (and highlighted in this document), are inline with the aims highlighted in the action plan, in making transport and travel cleaner, more efficient (and more energy efficient) and more safe and secure.

Action area 4 – "Integration of the vehicle into the transport infrastructure" is the main area where cooperative systems explicitly come into play, with Actions in the timeframe from 2011 to 2014 to develop and evaluate cooperative systems, define specifications for I2I, V2I and V2V communications, and define a mandate for the European Standardisation Organisations in order to develop harmonised standards for ITS (in particular cooperative systems) implementation.

The ITS Action Plan – Action Point 4

"streamlining and integration of these applications (transport of dangerous goods and live animals, digital tachograph, electronic toll collection and eCall (ed)) within a coherent, open-system architecture could yield better efficiency and usability, reduced costs and enhanced "plug and play" integration of future new or upgraded applications such as those in nomadic devices and those utilising GNSS services for advanced positioning and timing. This open system platform would be embodied in an open in-vehicle platform, guaranteeing interoperability/interconnections with infrastructure systems and facilities."[10]

Given that one Action Area out of six is dedicated particularly to the advancement of cooperative systems, it is clear that the European Commission sees this technology as the future, worth the investment, and willing to push forward its deployment (this can also be seen in the investment by the European Commission in projects relevant to cooperative systems).

We have seen that cooperative systems require many elements from different stakeholders in order for deployment to become reality. Projects such as CVIS (as well as Safespot and COOPERS) provide an all-round project, dealing with many different aspects, from the development of the technology, to testing, and how to get the product to market. However, there are many relevant projects which deal with perhaps one specific aspect of cooperative systems technology. These include projects about freight (FREILOT www.freilot.eu, smartfreight www.smartfreight.info), technology aspects (of the communication, of the hardware), data privacy, system architecture, etc. A comprehensive list of these projects can be found on the CVIS website www.cvisproject.org/en/links.

Freight regulations in city centres can be made easier with cooperative systems. Source: Gabriela Barrera, Polis

Given all of the projects related to cooperative systems, it is clear that there is a big drive from the European Union and from some national governments to push forward deployment of cooperative systems.

Cooperative Systems can also be seen to play a part in the Action Areas 1-3 as well, even if not mentioned explicitly:

- Action Area 1: Optimal use of road, traffic and travel data

Floating vehicle data obtained from cooperative systems will obviously play a role here.

- Action Area 2: Continuity of traffic and freight management ITS services on European transport corridors and conurbations

Within the Actions, location devices, standardisation of pricing and information flows are mentioned, and these are areas in which cooperative systems can play an important role.

- Action Area 3: Road safety and security

The area of safety can greatly benefit from cooperative systems: this has been examined through applications developed in projects such as Safespot, and has been discussed in Part II.

Action areas 5 and 6 relate to data security and ITS coordination & cooperation respectively.

The Dutch National Government see a large potential for cooperative systems, and have introduced cooperative systems within their national policy framework. The benefits they see as a road operator are primarily in terms of traffic management, and improved data collection from floating vehicle data, improved distribution of traffic information for road users, and extended coverage of information compared to existing systems.

They have two Actions with respect to cooperative systems:

- Action 1: create the market, with the help of government.
- Action 2: Large scale FOTs with smart vehicles and communication infrastructure.

Dutch policy makers are aware that cooperative systems are coming, and that getting involved in the deployment is crucial. Their roadmap for deployment is based on supporting road users while acquiring improved data for the road operator.

Source: CVIS

Deployment scenarios

It is unsure exactly how deployment of cooperative systems will take place: this will depend on how the technology advances, how standardisation issues are solved, how field operational tests perform, etc. For different deployment scenarios, broadly, the same set of elements need to be in place for cooperative systems to be deployed, but there can be different drivers that push forward deployment. Three deployment scenarios are considered by the CVIS project for the period 2015-2020: the scenarios are based on three different deployment approaches:

- deployment driven by public policy;
- deployment driven by commercial freight operations and
- deployment driven by private car users.

These three deployment scenarios obviously have different driving factors, and will affect the take-up of the technology. They are summarised below.

No stopping at any time. Except CVIS permit holders.
Source: Transport for London

Scenario 1 : Deployment driven by public policy

Main driving forces: Problems exist of congestion, need for increased mobility, environmental care and the need to reduce road accidents. Governmental authorities see that cooperative systems can help tackle urban transport problems.

Main actors: government and local authorities

Effect (for local authorities): Decreased fatalities, increased traffic flow, decreased congestion, decreased emissions, improved efficiency of existing infrastructure

Scenario 2: Deployment driven by commercial freight operations

Main driving forces: Freight managers realise that they can increase productivity and save money by employing cooperative systems. Increasing efficiency of freight (reducing waiting time and stop-and-start driving behaviour) can ease traffic flow and reduce emissions, so the European Commission also drives introduction of cooperative systems in the freight market in order to encourage meeting European-wide emissions targets. In urban areas, safety problems with freight and vulnerable road users is also of concern, and this is another driving force.

Main actors: freight managers, government (local, national, EU).

Effect (for local authorities): increased efficiency, decreased fatalities, increased traffic flow, decreased congestion, decreased emissions, improved efficiency of existing infrastructure.

Handheld in-car device. Source: Wikimedia Commons

Scenario 3: Deployment driven by private car users

Main driving forces: The consumer's constant desire for the newest and easiest technology may make handheld systems more successful than built-in in-vehicle systems. The automobile industry takes years to get concept vehicles to consumers. Private initiatives for development of CVIS system could come from the electronics or the telecommunications industries rather than the automotive industry.

Main actors: telecommunications industries, navigation service providers, service providers, consumers.

Effect (for local authorities): Every appropriately equipped vehicle acts as a sensor for the road network: benefits in terms of increased data obtained for local authorities.

London test site

The London Trial of CVIS (organised by Transport for London (TfL)) aims to establish whether innovative roadside to vehicle communications can be used to facilitate freight operation.

The test site was located on Earl's Court Road, on the outer edge of the London congestion charging zone, and there were 8 freight companies involved in the trial which ran from September – December 2009. Each freight operator had one or two dedicated vehicles for the trial on which they installed a CVIS OBU.

The purpose was for the vehicles to book the loading bay on Earl's Court Road in advance. The advantage for the freight operators of doing this was:

- freight companies had a pre-defined time when they could load-unload goods;
- when they had booked a time slot, then no one else was allowed to be in the bay at that time;
- If they needed to change the time of the reservation, they could do so by using their OBU;
- freight companies had a longer window in which they could load-unload goods (1hr instead of 20 minutes – a welcome by-product of the trial).

The CVIS trial members had special badges in their vehicles, and road signs marked the loading bay area as "CVIS permit holders only". Enforcement officers would receive notification by text message if a vehicle was in the bay which was not supposed to be.

Evaluation of the trial will be done now that the trial has finished.

Within each of these deployment scenarios, there are benefits for local authorities, but there is clearly a different level of government involvement in each of the different scenarios. Most benefit is achieved for local authorities if they take a lead in deployment, becoming involved in the development and (field) testing of the systems.

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Picture sources

For pictures for which the sources are not mentioned in the captions the sources are given below:

Page 6: Night cars. Source: Andrea Jaccarino, stock.xchng

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Acronyms

ANPR = Automatic number plate recognition

AVM = automatic vehicle monitoring

CALM = Communications Architecture for Land Mobile environment or Communications, Air-interface, Long and Medium range

CEN = European Committee for Standardisation

CVIS = Cooperative Vehicle-Infrastructure Systems

DSRC = dedicated short-range communications

ETC = Electronic toll collection

ETSI = European Telecommunications Standards Institute

FCD = floating car data (also FVD: floating vehicle data)

FOT = field operational test

FP6 = European Commission's 6th Framework Programme for Research

GPS= global positioning system

GNSS = global navigation satellite system

GSM = global system for mobile communications

HGV = heavy goods vehicle

HMI = human machine interface

I2V = infrastructure to vehicle communications

ICT = information communications technology

IPv6 = Internet Protocol version 6 (also IPv4)

ISA = intelligent speed adaptation

ISO = International Standards Organisation

ITS = intelligent transport systems

Java = object-oriented programming language

LDM = local dynamic map

OBU = onboard unit

OEM = original equipment manufacturer

OSGi = Open Services Gateway initiative – open standards organisation with a java based platform that can be remotely managed.

RSU = Roadside Unit

RTTI = real-time travel information

UTC = urban traffic control

V2V = vehicle to vehicle communications

V2X = vehicle to infrastructure or to vehicle communications

V2I = vehicle to infrastructure communications

VII = vehicle infrastructure integration (former name of US DOT's Intellidrive programme)

VMS = variable message sign

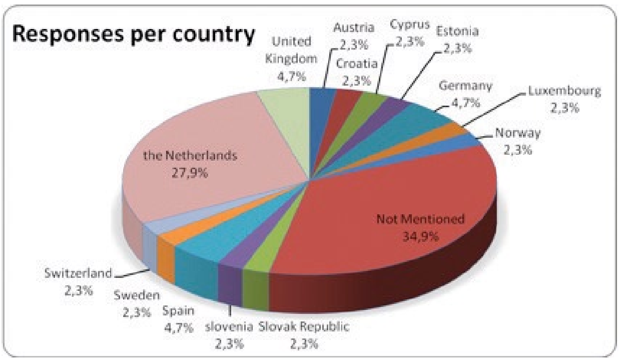
VPN = virtual private network

Wireless LAN = wireless local area network

Appendix 1

Respondents of road operator survey

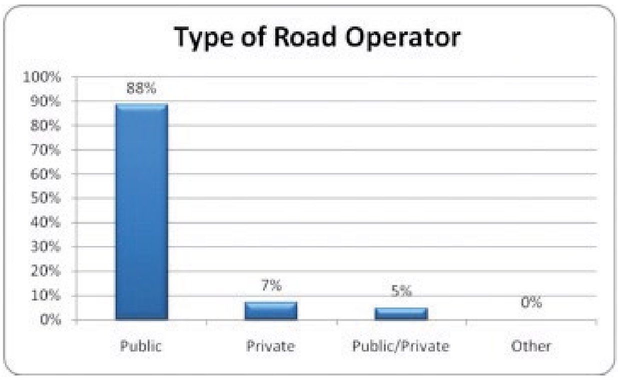
The questionnaire was anonymous, but respondents could voluntarily offer personal data such as the country they work in: 65% of respondents chose to do so:



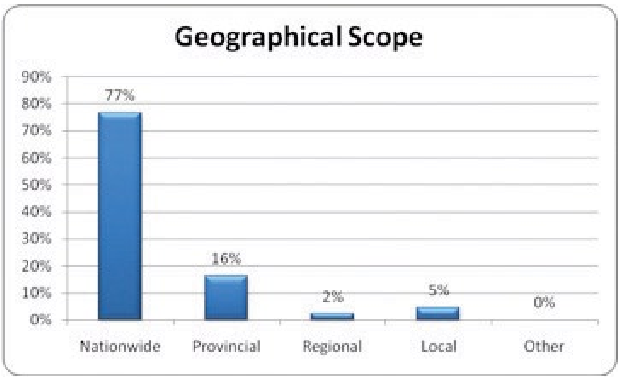
In order to get a profile of the surveyed road operators, questions were asked as to their field of work; what kind of road operator they were, their role within the organisation and on what kind of geographical level they operated. Questions of respondents' experience with cooperative systems and their number of year's experience were also asked.

Type of Road Operators

88% of the road operators were Public Owned companies, 7% were privately owned and 7% was a mixed Publicly/Privately owned.



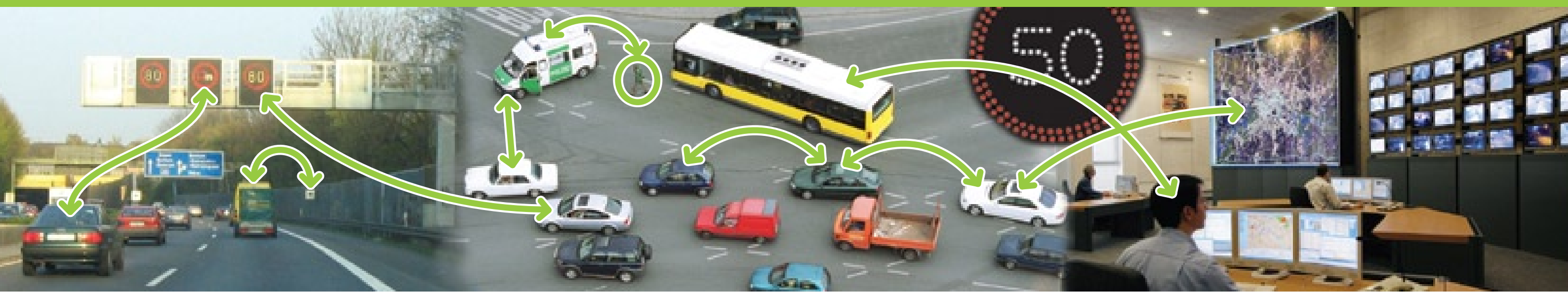
For the geographical scope, 76% of the Road Operators acted nationally, 17% acted on a provincial level, 2% on a regional level and 5% on a local level.



In summary: the majority of respondents worked for publicly owned Road Operators and had a nationwide focus. Approximately one third of the respondents were managers and another third advisors. Over 75% had more than 6 years experience within a road operator organisation, also 75% believe they had above-average familiarity with cooperative systems.

Cooperative Vehicle-Infrastructure Systems (CVIS) Project

CVIS is a major European research and development project with the aim to design, develop and test cooperative systems technologies. Cooperative systems are systems in which a vehicle communicates wirelessly with another vehicle (V2V – vehicle-to-vehicle communication) or with roadside infrastructure (V2I – vehicle-to-infrastructure communication or I2V – infrastructure to vehicle communication) with the ultimate aim of achieving benefits for many areas of traffic management and road safety. CVIS is supported by the European Commission under the 6th Framework Programme for Research and Development. The project's ambition is to begin a revolution in mobility for travellers and goods, completely re-engineering how drivers, vehicles, goods and transport infrastructure interact. The project has over 60 partners bringing together a mix of public authorities, software developers, system integrators, road operators, public transport operators, system suppliers, vehicle manufacturers, research institutions and users' organisations. The project started in February 2006, and with a large budget and a wide variety of stakeholders involved, it is an important project in the development and the deployment of cooperative systems technology in the EU.



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